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TWENTIETH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
State College, Pennsylvania

1956

FOR ADMINISTRATIVE USE ONLY

1956

Twentieth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania
Forage and Range Section
Crops Research Division,

Eastern Soil and Water Management Section
Soil and Water Conservation Research Division,
and
Cereal and Forage Insects Section
Entomology Research Division
of the
Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

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PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This twentieth annual report of forage crop research in the twelve Northeastern States marks the completion of the second decade of activity at the U. S. Regional Pasture Research Laboratory. It contains a brief summary of progress in the Region during 1956, covers activities at the Pasture Research Laboratory and at each of the state stations, and contains the reports of those Northeast Regional Committees concerned with forage improvement. These reports were furnished by the Laboratory Staff, by the Collaborators, and by the Chairmen of the Regional Committees, respectively. A new section is added this year, namely, "Useful Techniques". It is hoped that this feature will prove popular and that contributions will be made to it by all forage crop workers in the Region.

At the close of the year, Dr. R. J. Garber, Director of the Laboratory since its beginning in 1936, announced his retirement to take effect early in the new year 1957. At the same time he disclosed that he would join the faculty of the University of Illinois and engage in its International Cooperation Administration program in India. At the time this report is being prepared he has just reached his new headquarters at Madhya Bharat College of Agriculture and Research Institute, Gwalior, India. The good wishes of the Northeastern forage workers attend Dr. and Mrs. Garber in their new venture.

After nineteen years as soil technologist with the Pasture Laboratory, Dr. R. R. Robinson transferred July 1 to Beltsville, Maryland, to assume new duties as project leader in the Soil and Water Conservation Research Branch of the Agricultural Research Service. Mr. J. E. Field, Sr., assistant in plant chemistry, resigned. Three part-time assistants and graduate students who completed their work for the doctorate at the University are F. L. Barnett now with Kansas State College, Manhattan, R. B. Forbes, now with the Central Florida Experiment Station, Sanford, and Anna K. Stergaard, now with the University of Manitoba, Winnipeg.

Mr. Richard C. Newton joined the Laboratory Staff as project leader in entomology, a field of study long felt necessary to the progress of forage crop research. Mr. Newton is a graduate of the University of Connecticut and did graduate work at the University of Massachusetts. He has had research experience in Utah, Oregon, and Montana. Three assistants were added to the staff, Galen A. Motter in agronomy, Mrs. Eleanor L. Rowland in plant chemistry, and John A. Chemsak in plant pathology. Mr. Chemsak resigned later in the year.

Dr. Thomas S. Ronningen resigned as Collaborator from the Maryland Agricultural Experiment Station. He left the Maryland Station and joined the Office of Experiment Stations, A.R.S. He will be replaced as Collaborator by Dr. A. Morris Decker, Jr.

A Collaborators meeting was held at New Brunswick, N. J., July 10-11. Those present included the Collaborators, the Laboratory Staff, representatives of the A.R.S., and a committee of Northeastern Experiment Station Directors, consisting of Directors Campbell, Farrell, Guterman, and Starnes. The planned discussion centered around the future of the Laboratory research program. Each Collaborator presented an opinion of the direction of future research which was based on previous consultation with other workers at his station. After the presentation, a committee of Collaborators consisting of Phillips, Chairman; Keener, Murphy, Pohlman, and M. A. Sprague, summarized the recommendations in "The Report of the Regional Evaluation Committee." This report was approved by the Collaborators and presented to the Committee of Directors. It is on record that this report was later approved by the Directors at their regional meeting later in the summer at Burlington, Vermont. This report appears below.

The Collaborators also discussed the annual reports of "Pasture Research in the Northeastern United States" and recommended that they be continued more or less in their present form but with the closing date moved from February 1 to April 1. The Collaborators also expressed appreciation for the fine arrangements made by Dr. M. A. Sprague and his associates at the host institution and for the opportunity of seeing some of the forage crop research underway at the New Jersey Station.

REPORT OF REGIONAL EVALUATION COMMITTEE

The Committee, having carefully considered all the suggestions made by forage research workers in the Northeastern States, makes the following recomendations concerning future activity of the U. S. Regional Pasture Research Laboratory located at State College, Pa.

General Recommendations

1. The Pasture Laboratory should concentrate its efforts on basic research on factors affecting the improvement and utilization of forage plants.
2. It is important that the Laboratory serve as a source of improved techniques in forage plant research.
3. An entomologist should be added to the staff as soon as feasible. This position should be new and not a substitution for any existing position.
4. In the future, other fields, such as microbiology and plant anatomy and morphology, merit consideration.
5. It is suggested that at least one, preferably two, full-time research assistants or technicians be made available to each project leader as a means of increasing his effectiveness.
6. Provision should also be made for adequate equipment and facilities and enough funds should be provided for travel to enable project leaders to cooperate effectively with work underway at Northeastern Experiment Stations.

7. To provide for these increases it is recommended that the $100,000 annual limit in the U.S.D.A.-Pennsylvania Station memorandum of understanding be amended.

Specific Recommendations

A number of suggested problems for research in forages are listed below under the major research fields. It is realized that the solution of most of these problems will involve the combined efforts of specialists in two or more fields. Responsibility for work to be accomplished will of necessity be assumed by personnel in the respective fields. Items of major priority are listed as follows:

Agronomy. To study:

1. Relationship of climatic factors (particularly micro-climate) to (a) persistence and growth and (b) incidence of insect and disease pests.
2. Effect of management variations on competition between all species present.
3. Life history (including root) studies of the factors affecting seedling establishment, maturity and longevity.

Soils. To study relationship of the following factors to forage production:

1. Soil moisture and temperature.
2. Soil structure and compaction.
3. Soil nutrient status and nutrient uptake from native and applied nutrients.
4. Soil micro-organisms, particularly legume bacteria.

Plant Chemistry.

1. Continued study of the chemistry of cell walls and carbohydrates.
2. The development of rapid and accurate measures of screening plant populations for acceptability, quality and nutritive value. Cooperative research with animal nutrition specialists at appropriate stations will be necessary for the accomplishment of the last problem.

Breeding, Genetics and Cytogenetics.

1. Study the effectiveness of techniques of breeding.
2. Isolation and creation of new sources of hereditary variation suitable for use by plant breeders.
3. Continue genetic and cytogenetic studies.

Pathology.

1. Identification of causal organisms of specific diseases and the determination of their life history.
2. Estimation of importance of specific diseases.
3. Nature of resistance to specific diseases.
4. Development of methods of producing artificial epiphytotics.
5. Study the physiology of fungi, particularly toxin and pigment production.

Entomology.

1. Identification of insect pests which produce deleterious effects on the major forage plants and the determination of their life history.
2. Estimation of importance of specific pests.
3. Nature of resistance to specific pests and the development of methods of producing artificial infestations.
4. Studies of the mode of action of insect pests on the host plant.

Additional Problems Needing Attention

1. Basic studies of carbohydrate breakdown by micro-organisms in relation to availability of feed nutrients.
2. Nodulation studies with Rhizobia.
3. Secondary infections in close relation to pathological problems.
4. Study of growth patterns as influenced by environment, management and nutrition levels. These would presumably have pronounced effects upon animal acceptance, feed quality, and insect and disease relationships.

GENETICS AND PATHOLOGY

Alfalfa

Inheritance of Flower Color in *Medicago sativa*

The results of this study may be summarized as follows:

Complementary factors are involved in the expression of purple flower color. The occurrence of purple veins in white-flowered plants known to lack one dominant complementary factor suggests that vein color is not completely controlled by the genes for standard color. In the backcross population of purple F_2 x white, some purple-flowered segregates occurred with lighter or darker flower color than the parent. Cytological investigation indicated that such plants were not aneuploids. Acceptable fits of observed data to theoretical ratios were obtained only when tetrasomic or disomic-tetrasomic ratios were assumed.

Attempts to develop a white-flowered alfalfa synthetic are in progress.

Comparison of Progenies of Rhizomatous and Upright Alfalfa Selections

This planting was harvested for the third year. There was a further depletion of stands, particularly in the plots harvested 4 times annually at the early bud stage. Otherwise the results followed the same general pattern as described previously (1955 Annual Report, page 3).

Selection for Disease Resistance

The program of backcrossing disease resistance into Vernal and into Pasture Laboratory clones is being continued (1955 Annual Report, page 3). In addition to *Pseudopeziza medicaginis* and *Ascochyta imperfecta* a third pathogen, *Pseudoplea briosiana* was included in the program. The latter disease was severe in central Pennsylvania (and in the Midwest) in 1956 for the first time. Almost 100 percent of the plants in the disease nursery became infected.

In the spring 1956, approximately 5800 seedlings representing the first backcross population was screened in the greenhouse for resistance to A. imperfecta and reduced to approximately 2800 seedlings. These were transplanted in a disease nursery. During summer and fall the plants were rated for disease reaction and 180 plants were selected for further screening in the greenhouse. The number was reduced to 72 by artificial inoculations with the three pathogens. The second backcross generation and some F_2's will be established in the field in 1957.

Selection within Root-Spreading Alfalfa Populations

From a source nursery of 7500 plants of Rambler and 2 other Swift Current root-spreading strains established in 1955 and overseeded with bromegrass, 61 selections were made. Selection was based on rapidity of recovery, resistance to leaf diseases, and resistance to leafhoppers. These selections have been cloned for further evaluation, particularly with respect to root spreading.

Ladino Clover

Self-Compatible Ladino Clover

One hundred and thirty-five S_2 lines representing 10 families were classified for segregation for red vs. green leaves. Ninety-eight lines segregated and 37 were homozygous for the red leaf character. Two of the 98 lines gave ratios deviating significantly from 3:1 with segregations of 9:10 and 32:2. The total segregation for 9 of the 10 families also fit the expected 3:1 ratio. The total for one family, 156:31, deviated significantly from 3:1. These results generally confirm previous results. Another generation will be grown of lines and families with questionable segregations.

All S_2 lines, 17 and 12 respectively, from two families segregated for a lethal chlorophyll deficiency. The total segregation for green vs. deficient seedlings in the 2 families was 211:95 and 208:112, both giving a satisfactory fit to a 2:1 ratio. Seven of the 29 S_2 lines in these families gave ratios that deviated significantly from the 2:1. The 2:1 ratio along with the fact that all S_2 lines segregated for the chlorophyll deficiency suggests the presence of a balanced lethal mechanism.

F_1 and F_2 Yields of Trifolium repens

Yields of 6 single crosses and their F_2's seeded in plots with bromegrass in 1955 were obtained in 1956. The first harvest was not recorded because of some weed contamination. The mean yields of clover plus bromegrass at each of two aftermath harvests for the F_2 plots was 87.3 percent of that for the F_1 paired plots. The correlation between F_1 and F_2 yields in 27 sets of paired plots was +.768. The F_2 plots from the highest yielding F_1 showed the highest percentage reduction and yielded only 70 percent of the F_1. The estimated clover ground cover on F_2 plots in mid-summer averaged 84 percent of that for F_1 plots. These results point to the danger to be encountered in white clover if synthetics are constituted with too few clones.

Selection for Sclerotinia Resistance and for Persistence at Low Light Intensity

Mid-summer stand estimates (ground cover) were taken on 53 polycross progenies and 11 checks all seeded with orchardgrass and with bromegrass. The stands were generally good, averaging ca. 70% ground cover, in this the first harvest year. Significant differences in stand did exist, however, with the check, Idaho Common having only 29% ground cover and the polycross of 53-57 the highest with 79.2%. Five polycrosses had significantly better stands than Pilgrim (67.8%). Iowa synthetic and Western Composite were not significantly different from Pilgrim but Minnesota synthetic 2769 (59.3%) was significantly poorer than Pilgrim. It is expected that more severe stand losses will occur during the second winter following establishment.

On 2 replications of the above 64 entries which had been inoculated with Sclerotinia, severe stand losses occurred. The average percent survival for all entries was 12%. The average survival for all "Sclerotinia" polycrosses was 14.4% compared to 9.3% for "low light" polycrosses and 8.9% for check varieties. This indicates that the level of resistance in the present selections is not very high.

The amount of kill was higher in plots seeded with orchardgrass than in plots seeded only to Ladino. There was no indication, however, of an interaction between polycrosses and associations.

Limited seed was harvested of the "low light" synthetic and "Sclerotinia" synthetic. Seed of these two synthetics was made available for inclusion in N.E. 28 tests to be seeded in 1957.

In order to obtain information on the progress from selection at low light intensity, polycrosses of 10 clones selected for persistence at low light intensity and of 10 clones selected for resistance to Sclerotinia were evaluated in the low light chamber at 70°F and with a 15-hour daylength. Well established seedlings at a stage just prior to stolon initiation were placed in the chamber under 88 foot candles of light. After 48 days, all plants were surviving and appeared to be growing slightly. At this time

the light intensity was dropped to 52 f.c. More than 95% of the plants were still alive after 38 days at this light intensity. This indicates that well established Ladino seedlings can survive for an extended period of time at extremely low light intensity if other environmental factors are favorable.

Polycrosses differed significantly in seedling vigor throughout the study. At this low light level polycrosses of clones selected for persistence at low light intensity averaged higher in seedling vigor, produced more dry weight, had more leaves, and more plants recovered after clipping than polycrosses of clones selected for resistance to Sclerotinia.

A Stemphylium Disease of Ladino Clover

A leaf disease of Ladino clover has been studied and the causal agent identified as a new species of Stemphylium (S. trifolii). The symptoms are light brown necrotic areas up to 6 mm. across, usually marginal. Conidia of the fungus are light brown, rounded to subacute at the tips, and have 1-4 constrictions. Black sclerotial bodies may develop in the necrotic areas. In artificial inoculations many species of Trifolium (except T. dubium), alfalfa, and white sweet clover became moderately diseased.

Red Clover

Root Rot Complex

Survivors of plants which were established in the field in the spring of 1954 (1954 Annual Report, page 5) were dug in the spring of 1956. Approximately one percent had survived. Nine plants from 5 single crosses made good growth in the greenhouse. These plants represent germ plasm from Pennscott, Dollard, Purdue, and Rahn varieties.

The plants were multiplied vegetatively and crossed in all possible combinations during the winter of 1956-57. The seed will be sown in field plots in spring 1957.

Meadow Fescue and Perennial Ryegrass

Intergeneric Hybridization

The methods described (1955 Annual Report, pages 6-8) are being continued. Seed was harvested from the "amphiploids" of [Perennial ryegrass (2x) x Meadow fescue (4x)] which had been interplanted with Festuca arundinacea in hopes of obtaining both 42-chromosome amphiploid seedling progenies and 42-chromosome hybrids combining 21 chromosomes from the amphiploid and 21 chromosomes from tall fescue. Results indicate that the "amphiploids" were mixoploid for 21 and 42 chromosomes.

Approximate chromosome determinations using the root-tip smear technique were made from 524 seedlings. Seedlings with cilia on the auricles represent hybrids with tall fescue and derive 21 chromosomes from this species as pollen parent. The distribution of seedlings with various chromosome numbers was as follows:

	Plants with Chromosome Numbers						
Phenotype	14	21	28	35	42	56	Σ
Cilia on auricles	—	—	7	348	116*	—	470
No cilia	1*	3	8*	16	23*	2*	54
Total	1	3	15	364	139	2	524

*Plants saved for further study.

The meiotic behavior of selected plants will be studied. In addition, isolation plantings of the following types will be made: (1) 28-chromosomes with no cilia, (2) 42-chromosomes with cilia and (3) 42-chromosomes without cilia. Attempts will be made to establish fertility in desirable progenies within each of these groups.

Further attempts have been made to produce the allotetraploid directly from crossing induced tetraploids of perennial ryegrass and meadow fescue. Several seedlings have been obtained but their hybridity has not yet been established.

Bromegrass

Interspecific Hybridization in Bromus

The results on interspecific hybridization (1955 Annual Report, pages 8-9) have been published and may be summarized as follows: Diploid hybrids in the Bromopsis section of Bromus were, in general, morphologically intermediate, but instances of dominance and heterosis occurred. F_1 tetraploid hybrids between B. ciliatus and B. frondosus segregated into dwarf, semi-dwarf, and normal types. Diploid hybrids showed mean bivalent frequencies of 6.5 to 6.8 per MI cell and little irregularity in AI and quartet stages. Mean bivalent frequencies of 12.3 to 12.8 and moderate frequencies of I's, III's and IV's occurred in MI cells of F_1 tetraploid hybrids. Diploid hybrids were highly sterile, but were slightly fertile as seed parents in backcrosses. Tetraploid hybrids exhibited low fertility under open-pollination.

Hybrids between diploid and tetraploid species, though intermediate in most morphological characters, were generally more vigorous than their parents. At MI they exhibited mean frequencies of 6.66 to 9.63 I's and 4.78 to 5.48 II's per cell. Trivalents were moderately frequent at MI, and the AI and quartet stages were highly irregular. All triploid hybrids were sterile. Artificial amphiploids (2n = 42) showed bivalent frequencies of 18.93 to 20.10 at MI. Other chromosomes appeared as I's, III's or IV's. The amphiploids varied considerably in fertility. No further work on this project is anticipated.

Hexaploid Bromus inermis

The results of the meiotic studies of 4x, 6x, and 8x progenies of a tetraploid (polyhaploid) clone of B. inermis have been prepared for publication. Results of this study may be summarized as follows: Tetraploids, hexaploids and octoploids were found among open-pollination progenies of a tetraploid (2n = 28) clone interplanted with normal octoploid plants of B. inermis. The failure to obtain any aneuploids provides evidence that the functional B. inermis pollen possessed 28 chromosomes. The hybridity of hexaploid and octoploid progenies was established. Likewise, the role of a 28-chromosome plant of B. inermis in the origin of hexaploids was established.

The hexaploids were generally more irregular in meiotic behavior than normal octoploid plants and were characterized by a high degree of sterility. The 2 octoploid progenies presumably arose from the fertilization of an unreduced tetraploid egg by a normal reduced gamete from octoploid B. inermis. Although the chromosomes of these octoploids were usually sticky at meiosis, unpaired chromosomes, laggards, and micronuclei were less frequent than in most plants of B. inermis. One of the octoploids was fertile and the other set no seed under open-pollination.

The meiotic behavior of the three levels of polyploids was interpreted as favoring the hypothesis that octoploid B. inermis possesses two basic genomes each in quadruplicate.

Selection of B. inermis for Resistance to Pyrenophora bromi

Ten plants selected for resistance are being intercrossed in the greenhouse to provide materials for further selection.

Orchardgrass

Selection for Resistance to Foliar Diseases

Plots of restricted polycrosses of 4 clones selected for resistance to leaf diseases were established to compare their performance with polycrosses of a few clones selected primarily for vigor.

Dying-out of Orchardgrass

(In cooperation with H. B. Couch of the Pennsylvania Agricultural Experiment Station)

The project concerning the dying-out of orchardgrass is being continued (1955 Annual Report, page 12). Young plants of S37 orchardgrass were placed outside the greenhouse overnight (low of -7°C) and then inoculated with 35 isolates of fungi previously isolated from diseased orchardgrass and also with 5 from other forage crops.

The disease rating of the inoculated plants ranged from severe to no damage. While some of the controls were slightly damaged at the low temperature, most remained healthy except for a few frost killed leaves. All isolates of Fusarium roseum (6), Rhizoctonia soloni (3) and Pythium sp. (1) and non-sporulating (unknown) fungus caused moderate to severe damage to the orchardgrass plants.

Male-Sterility in Orchardgrass

Four male-sterile plants, tracing to the male-sterility study reported several years ago by Myers and interpreted as indicating cytoplasmic and tetrasomic inheritance, were used as maternal parents in crosses with inbreds possessing high pollen fertility. From a field classification of F_1s in which only plants which failed to shed any pollen were classified as male-sterile, the following ratios of fertile to sterile were obtained:

85:7, 87:6, 88:8, and 39:10. It will be noted that three of these ratios are suggestive of tetrasomic inheritance. Pollen analysis of some fertile and all sterile progenies is being made. All of the male-sterile plants produce either no good pollen or less than 10% of questionably good pollen. The male-fertile plants, on the other hand, vary from about 95% good pollen down to less than 50% good pollen. Critical chromosome number determinations, made at AI of meiosis, have so far indicated that male-steriles possess an aneuploid complement. The variable proportion of good pollen among plants classified as male-fertile suggests that some of these may also be aneuploids. The results so far indicate that the male-sterility available at this laboratory may be based upon aneuploidy rather than the interaction of cytoplasm and chromogenes as previously postulated. Further work on this problem is planned.

Reed Canarygrass

Progenies of 35-Chromosome *Phalaris arundinacea*

The results of this study (1955 Annual Report, pages 16-17) have been published and are here summarized. Chromosome numbers among the "polycross progenies" of natural pentaploids ranged from 28 to 56. Progeny means were higher than 35, suggesting a functional advantage for gametes with the extra chromosomes. The octoploids presumably arose as a result of fertilization of an unreduced egg (n = 35) by a pollen grain with 21 chromosomes. The natural pentaploid parents could have arisen in a similar way.

Chromosome number was not significantly correlated with leaf width but was correlated with date of anthesis ($r = .62^{**}$). Seeds of hexaploids and octoploids were generally heavier than those of tetraploids. Leaves of aneuploid progenies of normal tetraploids were paler green than those of tetraploids. Similarly, leaves of tetraploid progenies of pentaploids tended to be darker green than those of aneuploids. This concludes the study of this material.

Phalaris Interspecific Hybrids

The Argentine material (1955 Annual Report, page 13) was observed. A few plants in each of the three types of progenies survived the winter. These plants all appeared highly if not completely sterile.

Vegetative material of Ronpha grass, presumably an F_1 hybrid between *P. arundinacea* and *P. tuberosa* has been received from South Africa and is available to others of the region who might be interested in this hybrid.

Physiology and Host Range of Helminthosporia on Grasses

Studies in the physiology and host range of Helminthosporia on grasses (1955 Annual Report, page 14) have been completed. Physiological tests were designed to provide possible methods of differentiating species and isolates in culture. The species included H. avenae, H. teres, H. gramineum, H. dictyoides, H. dictyoides var. phlei, H. siccans, H. erythrospilum, H. catenarium, and Pleospora (Helminthosporium) phaecomes. The effect of two concentrations of malachite green and crystal violet dyes, a six and eight percent concentration of ethanol, and eight nitrogen containing compounds offered limited use in the delimitation of species. Pigments produced by the isolates of the above species were a significant characteristic in species delimitation. In studies of related species on cereals chloroform extracts of all isolates of H. avenae were red-orange, those of H. gramineum were orange, and those of H. teres were deep orange. All chloroform extracts of isolates of H. siccans produced a pink pigment while those of H. erythrospilum a somewhat similar species, were faint pink in color. Isolates from H. dictyoides var. phlei, and H. dictyoides on the fescues produced a yellow pigment, whereas chloroform extracts of H. dictyoides on the ryegrasses and a ryegrass-fescue hybrid were colorless. Isolates of Helminthosporium phaecomes, H. catenarium, and H. bromi did not produce a pigment. In cross inoculation studies, H. teres and H. gramineum infected barley, and H. avenae infected barley and orchardgrass, in addition to oats and tall oatgrass. Isolates of H. dictyoides on the fescues infected only those hosts, whereas, isolates of the fungus on the ryegrasses and a ryegrass x fescue hybrid were pathogenic on those hosts, as well as the fescues. H. siccans attacked the fescues, the ryegrasses, and the hybrid. H. bromi, H. dictyoides var phlei, H. erythrospilum, and H. phaecomes were pathogenic only to bromegrass, timothy, red top and orchardgrass, respectively. The above data indicate that H. dictyoides on the fescues and H. dictyoides on the ryegrasses and the hybrid constitute two forms of the pathogen.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Grasses

(In cooperation with T. G. Phillips
of the New Hampshire Station)

Studies on the cell wall constituents of forage plants are being continued (1955 Annual Report, page 16). Hemicelluloses were prepared from two or more samples each of orchardgrass, fescue, timothy, Kentucky bluegrass, reed canarygrass, bromegrass, alfalfa, Ladino clover, and birdsfoot trefoil by methods previously described. Over 90 percent of the total hemicellulose is extractable from the holocellulose by hot water and this fraction is being studied more intensively. That portion requiring alkaline extraction following the water extraction is less important in amount. The hemicelluloses are hydrolyzed and the constituent sugars separated by paper chromatography and each determined quantitatively.

The hemicelluloses contain four sugars and one or more uronic acids. In general, xylose is the most abundant sugar and galactose the least except that in alfalfa glucose is most abundant. In the different species of grass the sugars occur in similar proportions with an approximate ratio of 1:3:2:12 for galactose, glucose, arabinose, and xylose, respectively. In Ladino clover they occur in a similar ratio, 1:2:2:10 but alfalfa has 1:5:1:1 and birdsfoot trefoil 1:2:1:2. It is recognized that the hemicelluloses as prepared are probably mixtures and the above ratios are approximate and may vary in different organs of the plant. A number of bromegrass hemicelluloses, obtained from different organs and at different stages of growth are being analyzed. The hemicelluloses extractable by alkali have different proportions of the sugars than those extractable by hot water. Uronic acids, about 6 percent of total carbohydrate, have not been positively identified.

Measurement of Nutritive Value of Pasture Plants

Data are being collected on the chemical composition of pasture plants with the object of predicting nutritive values from a limited number of chemical analyses (1955 Annual Report, page 17). The materials available for study were supplied by various experiment stations with the cooperation of the technical committee of Northeastern Regional Project, N.E. 24. The most valuable single chemical determination that can be made in the laboratory to assess the energy value of forage may be lignin. From it may be calculated digestible dry matter or digestible organic matter of dried grass with an average error of about 2 percent or less. An equation (or equations) is being sought which will give a closer approximation to digestion values and which will apply to other types of forages.

Samples of grass were fractionated into alcohol-soluble and alcohol-insoluble portions. The alcohol-soluble portion is highly digestible. The digestibility of the alcohol-insoluble portion is closely related to its lignin content, r = -0.96. With some reasonable assumptions as to the digestibilities of the ether extract and of the alcohol-soluble portions and by calculating the digestibility of the alcohol-insoluble portion from its lignin content, the digestibility of the total organic matter of the grass may be calculated with an average error of less than 2 percent. While the improvement is not considered sufficient as a final goal, the improvement over the previous method of calculation is noted, especially in those samples which showed the widest discrepancy between the directly determined and the calculated values. Equations which may be used with reasonable success but which are expected to be improved by further studies are:

Digestible dry matter = 95.4 - 3.97x, where
x = lignin in percent of dry weight.
Digestible organic matter = 100.4 - 4.206x', where
x' = lignin in percent of organic matter.
Digestible organic matter =
0.4 (E.E.) + 1.0 (A.S.) + (0.01) (104.4 - 4.34x") (A.I.)
where E.E. = ether extract, A.S. = alcohol-soluble and A.I. = alcohol-insoluble, all in percent of organic matter, and x" equal lignin in percent of the alcohol-insoluble.

These results apply only to grass and only grass of fairly good or excellent quality was considered. The method of fractionation is being pursued for the purpose of finding a common system for use in forages other than dried grass, as legumes and silages. The lignin content cannot be the sole criterion of quality in different forages, because an alfalfa, for example, has a higher digestibility than a grass of the same lignin content.

Plant Climate

Microclimate studies (1955 Annual Report, page 18) were continued and increased attention was placed on factors affecting evaporation. Water loss by evaporation was measured with porous clay atmometer bulbs placed over a Kentucky bluegrass sod at heights of 3 inches and 5 feet and also at 3 inches within a stand of alfalfa cut for hay. Daily readings of water losses were taken from June 1 through September 30.

Evaporation was greatest during the 1st, 2nd and 4th weeks of June and was about 25 percent greater than during the other weeks in the summer. In general, evaporation 3 inches above the bluegrass was only about two-thirds that at 5 feet, and at 3 inches within alfalfa, 2 or 3 weeks prior to cutting for hay, evaporation was less than one-fourth that at 5 feet.

Studies are underway to find whether water losses at the 3-inch heights may be estimated from measurements taken at the 5-foot heights. The measurements taken have not been sufficiently specific to establish exact relationships between air and dewpoint temperatures, radiation, and wind movement in terms of evaporation covering a 24-hour period.

Quality of Artificial Light and Plant Growth

The use of fluorescent lamps for supplying light to plants grown under controlled climatic conditions raises the question of quality as well as light intensity. When the climate control chambers at the Laboratory were first used, a 200-watt mazda added to the 24 fluorescent lamps improved growth but made temperature control difficult because filament lamps provide high proportions of red and infra-red radiation which fluorescent lamps do not. The flurorescent lamps then used were the "daylight" type that provided light similar to north light or that received from a blue sky. They gave limited red and yellow wavelengths but were excellent for matching colors. To provide a more pleasing light for general use, a "white" lamp was developed that included more red and yellow light. To obtain more light from the same size lamp a "cool white" has recently been developed. This is slightly bluer than "white" but not so blue as "daylight". An experimental lamp providing pink light later became available for plant growth studies so that four different types of lamps could be compared in the control chambers: (1) one-half "pink" and half "cool white", (2) all "cool white", (3) one half "white" and half "daylight", and (4) all "white". The number of lamps used for each chamber was adjusted so that total light intensities in each were 410 foot candles.

Four legumes and two grasses were seeded and then grown for 7 weeks in well fertilized soil in 4-inch glazed pots. Six replicate pots thinned to include 5 seedlings were placed under each of the four light treatments and an additional treatment was placed in the greenhouse. Air temperatures were maintained at 70°F and the daylength was 16 hours. The top growth of all species was greatest under "pink" lights and least under "cool white". "White" and "daylight" were slightly better than "cool white" but were inferior to "pink". The six alfalfa pots yielded 5.6 grams in the greenhouse, 3.2 grams under "pink" and 1.9 grams under "cool white". The birdsfoot trefoil yielded 1.5 in the greenhouse, 1.0 grams under "pink", and 0.3 under "cool white". The average heights of the plants were in ranges similar to the weights.

Legume Seedling Establishment

This study (1955 Annual Report, page 19) was continued. Seedings of alfalfa and Ladino clover were made at monthly intervals from April to August. Observations and emergence counts were made at several weekly intervals.

Similarly to 1955 alfalfa emerged much earlier than Ladino clover. From the early May seeding 30% of the alfalfa seedlings emerged within one week while only 5% of the Ladino seedlings were evident. Maximum emergence of the planted seed from both species was completed 2 weeks after seeding when 28% of the Ladino seed had produced seedlings and there was 70% emergence from the alfalfa seed. Slightly better emergence of both species was obtained from the early April seeding. The emergence of seedings made June 5 was poor as a result of high temperatures and a low soil moisture that persisted until the latter part of the month. The stands of seedlings obtained from the June 29 and August 9 seedings were as good as those obtained from the April seeding. July and August temperatures were moderate and the precipitation was evenly distributed. While an adequate number of plants was obtained from the August seeding, the plants were still small in October at the end of the growing season.

Possible competitive effects of orchardgrass on Ladino clover were studied in a plot of orchardgrass previously used for hay. Ladino clover seeds were planted 100 per row 1/2 inch deep in 8 rows 18 inches long, for comparison with an adjacent plot containing alfalfa and Ladino clover planted similarly. Weekly observations indicated slightly better clover emergence on the orchardgrass plot where the soil had better physical structure. About 25% of the seeding made May 5 emerged as seedlings. By late October half of these seedlings had stolons ranging from 1/2 inch to 6 inches in length, a quarter had no stolons or only buds, and the remaining seedlings were small and weak. The variation between rows was small.

Gibberellic Acid and Germination of Orchardgrass and Ladino Clover

There have been frequent reports recently in the literature concerning gibberellic acid as a growth promoting substance. Trials of germination and early seedling growth with three concentrations of gibberellic acid (10, 20 and 40 ppm.) in water were conducted on moistened blotting paper in Petri dishes. The total germination of orchardgrass during the first 5 days was doubled by the gibberellic acid but thereafter the untreated and treated increased at about the same rate. The final and total germination of the treated samples was about 10% greater than the untreated. The rate of coleoptile growth was greater on the treated seedlings (29 mm. with treatment vs. 17 mm. with no treatment). Responses to the three concentrations of gibberellic acid were about the same.

Results of a similar trial with Ladino clover indicated only a very slight stimulation in the rate and total percent germination. Four days after the dry seed was moistened, the hypocotyls of the treated seedlings were between 3 and 15 mm. longer than those of untreated seedlings. Possibly the chemical may shorten the time Ladino clover seedlings are in the stage susceptible to damping-off fungi. To test this theory gibberellic acid at 10 and 40 ppm. and water as a control were pipetted onto seed of Ladino clover in steamed soil and in soil infested with Pythium debaryanum.

Seedlings from seed treated with the chemical emerged a little sooner and were taller and more spindly than seedlings from untreated seed. In Pythium infested soil pre-emergence damping-off was slightly increased in the treated series and postemergence damping-off was 5-10% higher than in the control series.

The Role of Hard Seeds of Ladino Clover in Natural Reseeding

Last year it was reported that certain stages of the process of softening hard seed could be reversed (1955 Annual Report, pages 20-21). This year studies were continued in an attempt to reverse the process after the seeds had been made permeable but before they were permitted to absorb water. Results obtained were negative.

Cutting Practices as They Affect the Persistence and Production of Alfalfa

During 1956 all plots in this trial (1955 Annual Report, page 20) were cut 3 times at the 1/10 bloom stage in order to measure any deleterious affect that may have remained from the previous years' early spring cuttings. Seasonal production in 1956 following the 1954 and 1955 treatments was between 4 and 5 tons of hay (15% moisture) per acre. There appeared to be a slight carry over of lower yields (1/4 ton less) from the plants cut in May at the prebud stage when compared to June cutting at the 1/10 bloom stage, but the differences were not large. There was no reduction in stand due to earlier first cuttings.

Chemical analyses for carbohydrates serving as reserves in roots have been made at several of the previous harvest dates. In 1952 when the first cutting was made on the different plots at 5 stages of growth from "prebud" to "mature", the roots generally contained increased percentages of reducing sugars, dextrin, starch, and total carbohydrates at the later dates of harvest. At the second cuttings, all made at the half bloom stage, the root carbohydrates were at about the same level, regardless of their level at the first cutting. Again no great differences were observed among the different plots at the last fall cuttings.

In 1953 the first cuttings were made at stages comparable to those of the preceding year and the composition of the roots at the different dates showed essentially the same relationship as before. At the time of the last cutting of this year, October 27, starch and total carbohydrates were lower in those plots cut earliest in the spring, namely at "prebud", than in those cut later. This may have been due to the length of the growth periods prior to the last cutting, 7 weeks for the "prebud" plots, and 10 and 11 weeks for the others. Even though the carbohydrates were somewhat lower in the "prebud" plots, persistence and production were maintained. In 1954 the same pattern was maintained as in 1952. At the fall cut the roots of the early-spring-cut plants were well supplied with reserve carbohydrates.

The Ranger and Vernal varieties which were first harvested in 1954 were similarly analyzed. In the first cutting at four stages of growth, reducing sugars, dextrin, starch, and total carbohydrates increased while sucrose decreased with maturity. At the time of fall cutting, the percentages of these carbohydrates (except sucrose) were higher in plants which had received their spring cut at the early bud stage than in those which had earlier or later spring cuts. These differences were closely correlated with the times elapsed since the previous cuttings. This again ranged from 7 to 11 weeks. No varietal differences were observed.

In general the chemical studies indicate that early cutting in the spring followed by summer cuttings at the 1/10 bloom stage does not cause any great diminution of reserve carbohydrates in the roots of alfalfa.

Three varieties of birdsfoot trefoil, Empire, European, and Viking, were similarly analyzed at four dates in the spring of 1954. In general, sugars, starch and total carbohydrates decreased with maturity but there were great varietal differences in rate of maturity and concentration of carbohydrates. There was much less accumulation of starch in trefoil than in alfalfa roots.

Reserve Carbohydrates in Alfalfa and Birdsfoot Trefoil

A companion study to the one reported above was carried out in the greenhouse (1953 Annual Report, page 16). Alfalfa plants in gravel culture were harvested at 5 stages of maturity, prebud to mature. The starch content of the roots increased with maturity. The tops of the remaining plants were removed at the different stages and root analyses again made after 5 weeks. Those cut previously at the prebud stage contained less reducing sugar, dextrin, starch, and total carbohydrates than those cut at more mature stages. Withholding moisture from plants grown in soil caused greater sucrose and less starch storage than in similar well-watered plants. In birdsfoot trefoil no compositional differences were apparent in the roots as a result of cutting tops at various stages of maturity.

Phosphate Placement and Temperature in Relation to Plant Growth

In regional experiments involving band placement of phosphate fertilizers, the responses have varied with the state where it was used (1955 Annual Report, page 21). To determine whether temperature may be a factor an experiment was conducted in the controlled temperature chambers at 50°, 60°, 70° and 80°F at 3 fertilizer levels, "banded" vs. "mixed" on soils of low and medium phosphate availability.

A Morrison loam provided a test soil extremely low in available phosphorus and very low in organic matter, but high in available potash. Trials were also made on a soil of moderate fertility obtained by adding dilute phosphoric acid to a portion of the soil and incubating for 3 weeks. Thus the two soils used in the study were the same except for the level of available phosphate. Calcium and magnesium carbonates were added as needed to bring the soil to pH 6.3 and the soil incubated at optimum moisture for three weeks before potting. Finely pulverized mono-calcium phosphate at different rates was applied either in a narrow band 3-1/2 inches long and 1 inch below the soil surface or mixed with the top 2-1/2 inches of soil. Red clover was seeded in rows across the pots, and thinned to 5 seedlings per pot. In the pots where the phosphate was banded, the seeds were placed directly above the fertilizer. All seed was inoculated with Rhizobium cultures. Twelve pots of each treatment were started at each temperature so that well replicated yields of both tops and roots could be obtained at each of 3 harvest dates.

In general, no response to phosphate fertilizer was apparent for the first 10 or 12 days after emergence regardless of the rate or placement. Thereafter the responses to phosphate became progressively greater both in terms of actual increase in yield and of percentage increases. Where phosphate was not limiting 60°F was the temperature at which greatest growth was made. Small differences in plant growth due to increased applications of phosphate were observed 3 weeks after emergence. After 7 weeks, responses to fertility were much more clearly defined. The responses to band placement of phosphate were particularly striking at low temperatures. At 50°F, the lowest amount of phosphate (17.5 mg.) when banded gave yields approximately twice as high as the highest rate (70 mg.) mixed with the top 2-1/2 inches of soil. At 70 and 80°F, yields from 17.5 mg. P_2O_5 banded and 70 mg. mixed with the soil were about the same. At 50°F a small amount of phosphate mixed with the soil increased yields but slightly, whereas at higher temperatures the yield increases were much larger. Phosphate that was applied in bands markedly increased yields at all temperatures.

Dry weights of roots and root distribution were highly correlated with yields of tops rather than specifically with phosphate placement. Where phosphate fertilization was adequate for good top growth, root growth was good and the roots were well distributed throughout the pot regardless of the placement of phosphate.

The results of chemical soil tests showed no differences in the available phosphate following prolonged incubation of the soil at temperatures of 50, 60, 70 and 80°F.

The results of this investigation indicate that when available phosphate is low, plants absorb phosphorus much more rapidly at high temperatures than at low temperatures. Good growth at high temperatures, therefore, can be obtained at relatively low levels of available phosphate. On the soil used for these experiments even the lowest rate of phosphate fertilization (equivalent to 25 pounds P_2O_5 per acre) apparently extended beyond the steepest part of the phosphorus response curve, particularly for the band application. This may partly explain why band applications of phosphate appeared to be less effective at high temperatures than at low temperatures. Good growth was obtained at low temperatures when the level of available phosphate was greatly increased to compensate for the lower rate of absorption. Band placement of soluble phosphates appeared to be particularly effective in increasing the concentration of available phosphate in the soil, and therefore, was unusually effective at low temperatures. These studies are being continued with phosphates of differing water solubilities.

Response of Various Perennial Forage Crops to Irrigation

An investigation to determine the effect of irrigation and fertilization on the total and seasonal distribution of yields on alfalfa and 5 grasses was continued into the third harvest year (1955 Annual Report, page 22). Due mainly to poor stands, particularly under irrigation, only 6 (alfalfa, orchardgrass, reed canarygrass, bromegrass, timothy and tall fescue) of the original 10 species were harvested in 1956.

During the 1956 growing season (April - September) rainfall was 5.2 inches above normal and 5.6 inches higher than 1955. While these differences may not be great the rains were much more evenly distributed. Temperatures for the same period were 2° below normal in 1956 and 3° above normal in 1955. This may partly account for the higher yields in 1956 on the non-irrigated plots. That less disease was observed on the plots receiving no irrigation may also explain in part why the yields from these plots were higher in 1956 than those that were irrigated.

Yield data for 1956 are given in the following table:

Species	No. of Cuttings in 1956	Lbs. per Acre, Dry Matter	
		Non-Irrigated*	Irrigated**
Orchardgrass	4	9874	8945
Reed Canarygrass	3	9443	9141
Bromegrass	3	9225	8967
Alfalfa	3	6606	5660
Timothy	1	4988	4175
Tall Fescue	1	2962	2930

* Average of 4 replications
** Average of 3 replications. Irrigated only once, June 1956.

Tall fescue and timothy recovered so poorly after the first cutting that they were discontinued. Kentucky bluegrass volunteered on all plots during the cool moist summer season of 1956. Reed canarygrass, bromegrass, and orchardgrass appear to be the species better adapted for midsummer irrigation. While orchardgrass yields were satisfactory in 1956 on the non-irrigated plots, production of alfalfa was less than expected from its performance in 1955. In general, the maintenance of stands was more difficult and production of both grasses and legumes decreased, under irrigation.

ENTOMOLOGY

As opportunity permitted from October 8 to December 20, the entomologist visited the Collaborators and entomologists working on legume and grass insects in the twelve Northeastern States. The most important species mentioned were the pea aphid, meadow spittlebug, potato leafhopper, alfalfa weevil, lesser clover leaf weevil, clover root curculio and other species of Sitona, clover root borer, seed weevils, and the spotted alfalfa aphid. The localized infestations of the European chafer and the alfalfa snout beetle were discussed in New York and several species of leafhoppers were mentioned as infesting grasses in Rhode Island.

REPORT OF COOPERATIVE RESEARCH

Title: PROJECT NE-13 - THE MECHANIZATION OF FORAGE CROP HARVESTING, PROCESSING, STORING AND FEEDING.

Leader: W. C. Wheeler, Chairman, Regional Technical Committee

Cooperators: Storrs (Connecticut), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, and the A.R.S., U.S.D.A., Agricultural Engineering Research Branch, Beltsville, Maryland

Accomplishments by the contributing projects are summarized under the general phases of the objective, namely: Harvesting, Processing, Storing and Feeding.

(1) Harvesting. Experimental values were used to establish power requirement curves for cutting individual stalks of grass under various conditions. Strain gage instrumentation continues and tests have been run to determine the cutting energy requirements for mowers under Connecticut field conditions. A high-speed motion picture camera is being used to analyze the cutting action. A prelubricated pitman crank pin bearing has given satisfactory service when used under field conditions.

A comparison of rotary-type harvesters and conventional mowers is being made by Massachusetts. Reduced drying time and faster harvesting operations are indicated for the rotary type of machine. Pick-up and stubble losses, suitability for baling and stock reaction to the short length of material are also under study. Comparison of moisture content between natural-cured swaths and swaths from commercial hay conditioners is being studied at Maine. A mower-windrower machine (West Virginia) mounted on the front end of a tractor and hydraulically controlled, combines two harvesting operations into one. Defects in design limited its operation during 1956.

Various air pressures and loadings were used for vehicles in flotation and compaction studies at Massachusetts. Less decrease in yield and less damage to grass stands were noted for 15 psi large section tires compared to 70 psi for standard tires. A marked difference in yield was found between treatment with 50 psi tires on a manure spreader and oversized tires (8-10 psi) on a loaded truck when used on plots that had been saturated by irrigation. Very little difference was noted in soil density for the various compaction treatments.

The results of a survey on bale handling methods and equipment in Maine points up the need for further investigation. Bunching methods for bales are under study with improved operation noted when an auxilliary power unit is used on bale loaders. Similar forage choppers equipped with

different pick-up attachments are being used (AERB-ARS) to harvest high moisture and wilted forages in an effort to determine the most efficient method of handling forage crops from field to storage.

(2) Processing. Wagon driers are being used for hay at New Jersey and Pennsylvania. The problems of air recirculation, down-draft vs. up-draft, hay density, source of heat, controls and type of wagon systems are under study. L.P. gas for operating engines used on hay drying fans seems to offer certain advantages. Batch and continuous baled hay driers using heated air are being developed at West Virginia.

Basic studies on the drying characteristics of chopped hay are being studied at New Jersey. The effect of temperatures on drying rates and nutritional value of alfalfa hay is being studied at Pennsylvania. Static pressures, temperatures and cost data on various fuels used in drying shelled corn are also under study. A tier duct arrangement for drying chopped hay in narrow deep mows gave satisfactory results under adverse weather conditions.

The effect of adding Kylage, corn meal, sodium meta-bisulfite or beet pulp to high moisture first cutting orchardgrass silage in silos was compared to two similar silages made without any treatment. Treatment of high moisture first cutting grass-clover silage with corn meal and with Kylage was compared to an untreated check silage. A comparison of chopped and unchopped second cutting grass-clover mixture stored in two bunker silos was made with regard to quality, palatability, feed value, storage and handling of material (AERB-ARS).

Plastic film containers offer difficulties in storage of silage by failure of containers, high cost of containers and large amount of work required for making a suitable stack. Very little spoilage has been noted in containers that remained intact (New Jersey).

(3) Storing. Flat belt conveyors and distributor mechanisms satisfactorily distributed chopped hay in mows at New York and Pennsylvania. An apron treading device increased the capacity and improved the operation of the New York elevator. New Jersey reports very satisfactory results with a number of silage distributors now in use. A flight-type bin loading conveyor distributor reduced labor and gave uniform distribution of grain in a "Quonset" grain storage building (Pennsylvania). Limited success has been obtained at New York with a tube-belt type elevator for long chopped hay. Studies to determine the power requirements and capacities of auger conveyors for handling grain and ground feed are being made. Use of a centrifugal clutch on the feeding mechanism of a blower has resulted in practically eliminating blower plugging. Plans are available for silage unloading metering equipment. Tests continue on commercial wagon unloading devices (Maine). An engine was added to a British-made forage blower by New Jersey. This blower combined with a self-unloading wagon was used to move semi-dry hay into storage without hand labor. A high-speed conveyor has been built by Maryland to use as a feeding device in the pneumatic handling of chopped hay.

Major difficulties to date have been with the introduction of hay into the air stream. Pipe friction losses for various airstream velocities have been determined. Less clearance between forage blower fan and the fan housing, and a larger size of pipe offer possibilities of improving this system of hay handling.

(4) Feeding. Upright self-feeder silo design features have been improved by New Jersey. A 16' x 48' unit has been constructed. This large unit used reinforced precast concrete sections for the base and included design features that facilitate the initial feeding of silage. A horizontal silo with sliding end gate to permit self-feeding worked extremely well at West Virginia. Much of the 22 percent loss due to spoilage can be reduced with better management. In New Jersey a 12' x 28' hay barn has been converted to a satisfactory grain self-feeder which was bulk filled. Grain flow control was excellent with very little adjustment needed and very little wastage experienced. Means of promoting flow of high molasses content ground dairy feeds in bulk bins are under study at Vermont. Investigation of new models of silo unloaders along with some already installed is continuing at New York and West Virginia. Data from 24 operating units indicated an approximate electric power use of 1.5 KWHr per ton for corn silage and 2.5 KWHr per ton for grass silage unloading (New York). The manger conveyor system at Vermont has improved by a design which allows the flights to return in a vertical position. A more compact control circuit and a redesigned electric fence cow trainer have further refined the system which will now mechanically handle hay and silage from storage. A silo was erected and a silo unloader installed to deliver silage to the feeding conveyor system. More accurate weighing of grain is possible with modifications that have been made on the Vermont grain metering device. In Pennsylvania electric hoist suspension of the flat belt mow conveyor permits its use for both mow loading and unloading of chopped hay.

USEFULNESS OF FINDINGS:

Low pressure tires for harvesting equipment permit more timely harvest under adverse field conditions. Determination of energy requirements for cutting forage should result in the design of more efficient mowers. Curing time for hay may be reduced by using rotary choppers or hay conditioners. Improved design of wagon drier systems is possible with presently-available data. More uniform distribution of chopped hay over a mow drying system results when elevators and conveyors are used. A tiered duct system offers a means of obtaining efficient air distribution in high narrow mows.

Labor for handling forage crops can be reduced by using conveyors, elevators and distributors for movement into storage; self-feeder types of silos; silo unloaders and conveyor systems for stanchion barns; improved self-unloading wagons and metering devices and the use in the field of mechanical bale handling equipment. Other contributions to the overall efficiency of feed and forage handling include: improved grain metering devices, self-feeder type grain bunkers, use of a prelubricated bearing on mower pitmans, automatic clutch control for feed drive on forage blowers and improved performance of engines used to drive fans by using L.P. gas as a fuel. Windrow pick-up equipment gave high hourly tonnage of dry matter for wilted and fresh-cut forages.

WORK PLANNED FOR NEXT YEAR:

(1) Harvesting. Compaction, improved equipment and methods for early season harvesting operations will be under study at Massachusetts and New Hampshire. The energy requirements for cutting forage crops will continue and will include a high-speed mower (Connecticut). Bale handling studies will continue at Maine. New Jersey will continue work with moisture-indicating devices. Several states will study forage-harvesting methods.

(2) Processing. Crop drying studies will continue at New Jersey, Delaware, Pennsylvania and West Virginia. AERB-ARS will continue work on ensiling and preservation of high moisture silage. Experimentation in the use of plastic film for silage packaging will be carried on at New Jersey.

(3) Storing. Various blowers, conveyors, elevators and unloading devices will be under study at New York, Maine, Maryland, New Jersey, Pennsylvania and West Virginia. Study will be continued by AERB-ARS on the efficient handling of forage crops from the fields to storage. Investigation of bulk grain bins will continue at Vermont.

(4) Feeding. Silo unloader studies will continue at New York and West Virginia. Studies of self-feeder structures will continue at New Jersey. Manger conveyor and the grain metering device studies will continue at Vermont. Work on integrating the silo unloader in the feeding system will be done.

Title: PROJECT NE-18 - ECONOMICS OF FORAGE PRODUCTION AND UTILIZATION

Leader: G. E. Toben, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Delaware, Maine, Massachusetts, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont and West Virginia Agricultural Experiment Stations

This project was activated July 1, 1954. Since that date was in the middle of the cropping season, some phases of the research were not started until the spring of 1955. Since then all states have collected data and published one or more reports based on the work supported by the project. The project has four objectives. State projects contribute to one or more of these objectives. Progress was made on all four.

Objective I - Present Patterns of Production, Harvesting and Utilization: A regional summary of the patterns of production and utilization of forage crops in the northeast was started during 1956. Information summarized for this report includes land use and livestock production in the northeast. A more complete analysis is being made of the roughage programs on dairy farms in seven of the states. Emphasis in this analysis is placed on

relationships between size of herds and other farm management factors within areas of the region. This analysis includes land use patterns, forage harvesting equipment, labor force and crop and livestock production. While the balance between grain and forage crops in the cropping plan varies throughout the region, the proportion of the total land in silage crops generally was greater as the size of dairy herds increased. Farmers with alluvial soils had twice as much silage in their roughage program as farmers with acid till soils. Farmers on high lime soils had more grains or more corn silage than those on low lime soils.

Objective II - Input-Output Relationships in Forage Production: The physical and economic return from alternative roughage programs is an important phase of this study. Inadequate pasture limits dairy income on some farms. By preparing alternative budgets on selected farms it was determined that income could be raised with improved roughage programs. One way is to harvest excess forage as silage from a pasture in early spring for late summer feeding. Changes in seeding mixtures can also increase farm returns more than costs. Harvesting costs are important considerations in roughage programs. These costs were analyzed as a part of the total farm situation and were also evaluated by selected items. At one station, 14 items of equipment were included in the analysis. Farmers in the southern part of the region who followed a system of cropping in which most of the land was in hay crops had smaller businesses than other farmers. Farmers with higher proportions of the land in grain crops, had large sizes of business. One study tested the extent to which pasture production can be estimated from the denseness of the sward. It was found that as ground cover increased the annual dry matter production also increased. On permanent bluegrass pasture it was concluded that production could be estimated from the percentage of ground cover when the cover was less than 70 percent. Above 70 percent the method is less reliable. However, this method has usefulness in that almost three-fourths of the permanent pasture acreage in the northeast has less than 70 percent cover. For improved pastures of orchardgrass-Ladino clover, the ground cover is only a general guide for estimating production.

Objective III - Input-Output Relationships in Forage Utilization: Different barn feeding roughage programs showed relatively small differences in feeding costs per cow per day. However, cost differences which reflected substitution of forage for grain, made possible because silages were better quality than hay, reduced the costs of feeding. Information was obtained from a few farmers whose cows did not go to pasture. This included farmers who practiced soilage and who ensiled for summer feeding. When land conditions do not interfere with intensive use of forage harvesting equipment, the summer feeding of silage is more profitable.

Objective IV - Economic Effects of Alternative Roughage Programs on the Farm Business: Differences in alternative roughage programs are reflected in farm income. The effects of different programs are being analyzed by comparing farms with different systems. They are also being compared by budgeting different programs for selected farms and comparing budgeted results with experience. In some instances the budgets are being developed by the researchers

with suggestions from farmers and agricultural workers other than the research leaders. Research on this phase of the problem depends on input-output data being obtained under the other three objectives.

Published and unpublished results of the research are being used in all the cooperating states. They are being used in work with individual farmers and in group meetings with farmers, urban people and other agriculturists. These findings are also being used by the researchers, county agents, agricultural teachers and other professional agricultural workers in farm planning.

Objective one will be completed during the next year. Collection of data dealing with specific phases of the other objectives will also be completed. Data from this study will be used in connection with budgeting alternative roughage programs. The first regional report is planned for publication in 1957.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: C. R. Richards, Chairman, Regional Technical Committee

Cooperators: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, West Virginia and Vermont Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Dairy Husbandry Research Branch and the State Experiment Stations Division, A.R.S., U.S.D.A.

The objectives of the project are: (1) To evaluate various forages grown under known conditions and harvested at specific stages of maturity by determining digestible protein and digestible energy; and to measure the annual harvest of nutritive value by taking into account both acreage yield and nutritive value per unit of dry matter. (The determination of digestible dry matter may be substituted for digestible energy in grazing experiments.) (2) To develop methods for the nutritive evaluation of forages; these to include the use of small animals and chemical analysis. (3) To conduct animal production trials simultaneously insofar as possible.

The following state experiment stations have contributing projects to this regional project: Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Rhode Island. The United States Regional Pasture Research Laboratory also has work of a related nature as does the Dairy Husbandry Research Branch.

In furtherance of objective 1, Maryland, Delaware, Rhode Island and Pennsylvania have determined, or are in the process of determining, the digestible energy and digestible protein of first cut alfalfa harvested at three different stages of maturity. The experimental animals being

used are steers, sheep and heifers. Rhode Island is also making a similar study with red clover. In general, the digestible energy and digestible protein contents are highest in the earliest cut material and lowest in the latest cut material. The acceptability or palatability also follows the same trend. The yield of nutrients from the first harvest, however, is greater at some of the later growth stages than it is at the very early stages. Massachusetts using milking cows, has determined the digestible protein and digestible energy of two hays; one containing considerable legume, the other predominantly grass. New Jersey has compared the nutritive value for sheep of aftermath orchardgrass grown with 100, 200 or 400 lbs. of nitrogen added per acre to the nutritive value of a second-cut alfalfa hay. There was as high or higher protein content in the alfalfa hay as in any of the orchardgrasses and the protein of alfalfa was of higher digestibility; however, there was approximately 9 percent more digestible energy and 10 percent more T.D.N. in the fertilized orchardgrasses than in the alfalfa hay. Other management practices could alter this relationship. New York is comparing the response with high and low nitrogen fertilization on timothy using sheep as the experimental animals.

Under objectives 1 and 2, New York is continuing to study the effect of date of cutting on the digestible energy of forages. The date of cutting appears to be more important in predicting the digestible energy than is the species of forage. The percent of digestible dry matter may be expressed by the equation $Y = 85.1 - 0.47 X$, where Y = digestibility of dry matter (percent) and X = harvesting time in days after April 30 but before July 15. This equation is based upon seven years' work using some 83 samples representing 8 forage species. The standard deviation from regression is 1.64 percent. The New Hampshire station has made the following determinations: Total digestible nutrients, digestible dry matter, digestible energy, metabolizable energy, and net energy. With five roughages studied, the above methods all rated them in practically the same order. Pennsylvania has determined the digestible dry matter, the digestible energy, digestible protein, T.D.N., and metabolizable energy on the same five roughages which were supplied to them from New Hampshire. The same determinations were made on three forage samples from Maryland. Cattle were used as the experimental animals in New Hampshire and Maryland, while sheep were used in Pennsylvania. The data indicate that with these materials there was more variation within species than there was between species. Delaware has underway comparative evaluations using rabbits and sheep.

Under objectives 1 and 3, Maryland has conducted lactation studies with the forages in which the digestible protein and digestible energy were determined as previously mentioned. The full-bud stage of alfalfa was found to be worth 94 percent of the one-tenth bud alfalfa for milk production and maintenance of body weight and that the one-half bloom alfalfa was 87 percent as valuable as the one-tenth bud. The acceptability by the cows also decreased with the increased maturity. The Massachusetts station has made trials using two types of second cutting hay--the first type containing considerable alfalfa and clover and the second type predominantly grass. Higher milk production was obtained from cows fed the first type hay. This

perhaps can be explained by the difference in digestible energy content of the two hays.

The results of these and future studies will aid in making recommendations to farmers of the comparative nutritive value of the various species and varieties of forage best to grow in utilizing the potential forage production of their farm. It will also add to the evidence on nutritive value of forage grown under different production and management practices.

A more critical evaluation will be available on the digestible energy value of forages determined with different species of animals. Evidence in the literature does not firmly establish the applicability of values where determined with different species.

In the New York area, the finding that the energy value of first growth forage (in terms of digestible dry matter) is closely related to the date of cutting, has been adapted for use in practical feeding. This will allow farmers to determine more accurately how much concentrates to feed and how much protein a concentrate should contain when feeding livestock.

The work will be continued as at present outlined. The Vermont and Maine stations have submitted contributing project outlines which have been approved by the technical committee. West Virginia is submitting a project outline subject to approval by the executive committee.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST

Leader: R. P. Murphy, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maine, Maryland, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Field Crops Research Branch, the State Experiment Station Division, A.R.S., U.S.D.A., and the American Seed Trade Association

The state experiment stations which cooperated in 1956 in the tests are: Orchardgrass - New York, Pennsylvania, Maryland; smooth bromegrass - New Hampshire, New York, Pennsylvania; timothy - New York; alfalfa - Maine, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, West Virginia; birdsfoot trefoil - Vermont, New York, Pennsylvania, New Jersey; and Ladino clover - New Hampshire, Maryland.

The general breeding procedure followed with these crops is to test selected clones, their polycross progeny, and selected experimental synthetic varie-

ties produced from the elite clones as determined by their performance and their progeny's performance. The selected clones represent the best that are available from the various experiment station research programs. Their value on a regional basis is determined through this project and the experimental synthetics are compounded from a selected elite sample from the entire group tested based upon their regional performance. Selection is based upon yield, sub-regional adaptation, disease reaction, persistence, plant type, seasonal distribution of production, maturity and other important characteristics. Other experimental varieties and standard varieties in use are used as checks.

The experiments with orchardgrass, smooth bromegrass and birdsfoot trefoil are most advanced. Those with alfalfa follow and those with ladino clover and timothy are being initiated at this time.

With orchardgrass, after two years of testing, several of the selected clones are superior to the check varieties in common use. On the basis of these results three new experimental synthetics (1. early-, 2. medium-, and 3. late-maturing) have been compounded for test. Among the new experimental synthetics N.Y. D (late) appears promising and will be tested more extensively. For a late-maturing variety, it is high yielding, leafy and relatively free of foliage diseases.

With smooth bromegrass, after two years of testing, several of the selected clones are superior to the check varieties in common use. On the basis of these results three new experimental synthetics (1. over-all merit and aftermath, 2. creeping growth habit, and 3. bunch growth habit) have been compounded for test. Among the new experimental synthetics N.Y. B (named Saratoga and released in 1955) appears promising and excels check varieties in amount of early spring growth, aftermath production, and establishment. N.Y. H is almost equal to Saratoga for forage production but is unsatisfactory in seed production. Considerable loss of stand in the bromegrass plots occurred during the past growing season at New Hampshire. The cause or causes of this are not known. In general the higher yielding plots in the previous year showed the greatest loss in stand. The loss in stand did not occur in the clone test (spaced plants).

With birdsfoot trefoil, after two years of testing, very few of the selected clones appear promising. Data on yield were obtained only from the New York test. All the tests at Vermont showed extensive killing over winter. The tests were planted on a light sandy soil and this type of killing has occurred previously at this station on this site. A hypothesis for the cause of the killing is that it is due to Sclerotinia. Among the early varieties Viking appears to be the best but several of these need further testing especially Mansfield and LC-54 (N.Y.). Among the late types the 4n Lotus tenuis (Vt.) seems to merit further testing especially under different management systems and for seed production.

With alfalfa, good establishment of plots was obtained at five of the seven stations (Connecticut doubtful and West Virginia will seed next year). Clone tests have been established at all stations except West Virginia. Establishment and growth were so good at Maine and Pennsylvania that yields were obtained from spring-seeded plots.

With Ladino clover and timothy initial increase of materials for regional tests were made by the appropriate stations. With Ladino clover, seed of two experimental varieties was produced last year by the U. S. Regional Pasture Research Laboratory. Polycross seed of Ladino clover was produced in limited amounts from 21 clones by Maryland. Polycross seed of selected clones of timothy will be produced in 1957 by New York from plantings made in 1956.

The growing season of 1955 was above normal in temperature and below normal in precipitation whereas the 1956 one was the reverse. Some differential response in performance among varieties has occurred at given testing sites for the two years. More noticeable is the differential response which is found in performance among varieties tested at the various stations. This is most notable for orchardgrass but is probably existent for birdsfoot trefoil. To evaluate these breeding materials adequately it seems that testing under additional management systems and locations is needed.

The results from the tests to date give further evidence on the superiority in the region of such newly released varieties as Potomac orchardgrass, Saratoga smooth bromegrass, and Viking and Mansfield (early-type) and Empire (late-type) birdsfoot trefoil. Empire has been brought into the National Foundation Seed Project on the basis of joint recommendations by the Northeast and North Central States. A number of promising selected clones have been identified and are being used to formulate new experimental synthetic varieties of orchardgrass and smooth bromegrass. Several experimental varieties now under test appear promising and will be tested further, especially with orchardgrass, smooth bromegrass and birdsfoot trefoil. Narragansett alfalfa and Pennscott red clover which were tested on a regional basis under NE-10 (the regional project which preceded NE-21 and NE-28) are currently very important and valuable varieties in the Northeast.

The tests with orchardgrass, smooth bromegrass, birdsfoot trefoil and alfalfa will be continued. Tests with Ladino clover and additional tests of orchardgrass, birdsfoot trefoil, and alfalfa will be established. Materials for timothy tests will be increased for regional tests in 1958. Expansion of research with existing crops is planned rather than working with additional ones. Promising experimental synthetics will be tested under additional management systems and at additional sites by cooperating stations. In addition, some cooperating stations for a given crop will formulate experimental synthetic varieties based upon the performance of the parental clones at the given station. These will be tested throughout the region. These tests should be useful in determining the significance of local or subregional adaptation vs. wide or regional adaptation.

Title: PROJECT NE-29 - ESTABLISHMENT AND MANAGEMENT OF PERENNIAL FORAGE SPECIES AND VARIETIES FOR PERSISTENT PRODUCTION IN THE NORTHEAST.
SUB-PROJECT I - SEEDLING ESTABLISHMENT AND EARLY DEVELOPMENT OF FORAGE GRASSES AND LEGUMES AS AFFECTED BY CULTURAL TREATMENT.
SUB-PROJECT II - PERSISTENCE, PRODUCTIVITY AND GROSS NUTRIENT VALUE OF PERENNIAL FORAGE CROPS AS INFLUENCED BY MANAGEMENT PRACTICES.

Leader: H. A. MacDonald, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maryland, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Field Crops Research Branch, the Agricultural Engineering Research Branch, and the State Experiment Station Division, A.R.S., U.S.D.A.

This regional research project was initiated July 1, 1954, as Phase I and II of Regional Research Project NE-21. It was reorganized July 1, 1955 as Regional Research Project NE-29. The primary objectives are to determine (1) the effect of various methods of seeding and of fertilizer application and placement on the establishment and early development of forage crop seedings, (2) the effect of different cropping and clipping practices for plant competition control, on establishment, early development and winter survival of forage grasses and legumes when seeded with and without a companion crop, (3) the interrelationship of species, cultural methods, management systems and climatic factors as they influence seeding establishment, (4) the influence of seeding methods and management practices on the eventual yield, composition and persistence of forage crop seedings, and (5) to develop techniques and practices which will result in more effective, reliable and economical forage crop establishment and production.

Sub-project I - Seeding Establishment. Investigations are being carried out relative to seed placement, fertilizer composition, rate and placement at Connecticut, Maryland, New Jersey, New York, and Pennsylvania. Studies on the first year management of established seedings are under way at Connecticut, Maryland, New Jersey, New York, Pennsylvania and Vermont. In addition to the seedings established in 1954 and 1955, new experiments were initiated at the above stations in the spring of 1956. Much of this work was done with the aid and cooperation of the Agricultural Engineering Research Branch, Agricultural Research Service, U.S.D.A. which provided specialized seeding equipment.

Successful seedings were obtained at all cooperating stations in 1956. Where limited failure occurred it was attributable to insufficient soil moisture at or following seeding. The season was favorable for plant growth and development throughout most of the region having adequate moisture and below normal temperature.

At most stations drilled seed placement gave quicker emergence and more rapid early seedling development. This did not necessarily result in higher plant population or improved yield however. The influence of fertilizer composition and rate of application was found to be largely related to local soil conditions, basic field fertility level and moisture conditions. Where the field fertility was low, material response resulted from applications at the time of seeding, particularly phosphorus. In the more northern areas material response resulted from increased fertilizer application both of composition and rate.

Band fertilizer application gave significant improvement in stand and early growth in most states. One of the most significant results of band placement was the reduced weed population and competition between the rows. This was particularly important in 1956. Weed competition was greatly reduced during the summer where band placement was used in the northern portion of the region.

The use of a companion crop of oats depressed the vigor of seeding establishment and yield except under the best growing conditions for the seeding or where the companion crop did poorly. Pure forage seedings were almost always best. The grass portion of the forage seeding was found to be particularly sensitive to companion crop competition.

Frequent clipping of the seeding in the first year reduced the stand and vigor of the alfalfa-bromegrass mixture and to a lesser extent of the birdsfoot trefoil-timothy mixture. Ladino white clover was favored by frequent clipping while orchardgrass was injured.

Weed growth competition was often found to be more severe than companion crop competition. The combined influence was often disastrous. The degree of weed injury depended upon the nature of the weed, growth habit, population and the time of weed growth in relation to the development of the forage seeding. As the season progressed different weed species became specific problems due to differential response to ecological factors such as light, temperature and moisture. One clipping appeared to give the most dependable improvement in seeding establishment and vigor. The time of clipping most conducive to strong seeding establishment depended upon the development of the forage and that of competing plants. This is being investigated further.

Sub-project II - Persistence and Productivity. The results of this study are still preliminary since the treatments have to do with persistence and production. To date the results indicate marked difference within the region as to the optimum harvest management of the crops involved. Too frequent or early fall harvest injured alfalfa at most stations.

Evidence indicates that proper harvest management must be related to plant characteristics and their physiological response to the environment. The most advantageous cutting treatment will thus depend upon the species, the variety, the immediate environment and the location within the region. Ladino white clover maintenance was favored by early harvest. The results

of other treatments are not conclusive at this time. At least two more years of study are needed before valid conclusions can be drawn.

Much information has been obtained from this study which, when properly interpreted in relation to specific condition of soil, climate and plant competition, can greatly improve forage crop seeding establishment, persistence and production. Basic information has been obtained which will provide guides to the evaluation of local conditions. While the results obtained are as yet not complete they show that improved, if not assured seedings, can be obtained in most areas through band placement of seed and fertilizer. Seeding survival and development can be enhanced through clipping management practices designed to favor seedings through the reduction of competition from other plants. The findings indicate not only the need for precision seeding equipment but also show the required characteristics of such equipment.

The results of crop management point the way to improved farm practice which should result in higher persistent production of quality hay and pasture. The results show that the region can be classified into areas of different climatic characteristics for most efficient forage crop establishment and management. Rather detailed records have given a picture of the attributes of crop climate in the region.

Experiments on seedling establishment and forage crop management will be repeated at each of the cooperating stations in order to obtain a wider sample of influencing conditions. Supplementary and more detailed studies of unit factors involved will be conducted. Further data will be collected and recorded from the studies now in progress. Attempts will be made to improve the methods and techniques used in order to obtain more specific and valid information. Further attempts will be made to evaluate the intensity of the problems involved throughout the region. The data already accumulated will be analyzed and prepared for early publication. The N.E. 29 project will cooperate with other research projects in the region, in order to promote research economy and at the same time arrive at valid conclusions of both general and specific application.

PASTURE RESEARCH IN THE FORAGE AND RANGE SECTION
BELTSVILLE, MARYLAND

Title: ORCHARDGRASS BREEDING (1954 Annual Report, page 20)

Leader: A. A. Hanson

Potomac orchardgrass is being increased under the auspices of the National Foundation seed Project. A new clonal planting of Potomac was established at Beltsville, Maryland in the fall of 1956 for the production of breeder seed. A duplicate clonal planting was established at Logan, Utah, in the summer of 1955. The planting at Logan will be used to study the possibilities of producing breeder seed under irrigated conditions. Comparisons between Beltsville, Maryland and Logan, Utah will be based on progeny performance. Five late maturing, disease resistant clones (1954 Annual Report, page 20) were sent to Corvallis, Oregon for the production of seed for plot testing. Heading and flowering of these late selections has never been satisfactory at Beltsville.

Title: BREEDING ANNUAL FORAGE GRASSES

Leader: A. A. Hanson

The large sample of disease resistant sudangrass lines selected at Beltsville, Maryland have been reselected for the past three years on the basis of prussic acid potential, disease resistance, maturity and leafiness. These lines have been sent to sudangrass breeders located at Chillicothe, Texas, Brawley, California, Fargo, North Dakota, and Lafayette, Indiana. A top cross nursery will be planted at Beltsville in 1957. In addition, 100 experimental male sterile lines selected at Chillicothe, Texas will be evaluated for prussic acid potential.

Hybrid #1 pearl millet, developed at Tifton, Georgia, has continued to look very promising in the uniform grass testing program. Hybrid #1 is the first generation increase of a 4 line synthetic. Plans are being made to release this variety in 1958. It should perform well in the southern portion of the northeastern region. Hybrid #1 planted in 42-inch rows at Beltsville produced significantly higher yields when the within-row spacing was 4 inches as compared with 6, 8, 12 or 18 inches.

Title: BREEDING PERENNIAL FORAGE GRASSES

Leader: A. A. Hanson

Studies on the use of thermal neutrons in grass breeding (see orchardgrass, 1954 Annual Report, page 20) has been expanded to include tall fescue, Kentucky bluegrass and smooth bromegrass. Some interesting mutants have been observed in the first generation. These studies are being continued. A very coarse, vigorous selection of tall fescue is being increased for possible use in soil conservation programs. Restricted polycross progenies of three meadow fescue clones, selected for immunity to rust at the U. S. Regional Pasture Research Laboratory, have been planted in an increase block (1955 Annual Report, page 8). Preliminary adaptation tests will be conducted with Andropogon spp. in 1957, preparatory to initiating hybridization studies. Greenhouse studies have been conducted on the interaction of type, soil fertility and defoliation intensity, on persistence and yield of tall fescue clones. These studies will be continued.

Title: OBSERVATIONS ON QUAKER COMFREY (SYMPHYTUM PEREGRINUM)

Leader: A. A. Hanson

An observational test was established in 1956 in response to the current interest in Quaker Comfrey. Planting stock is being distributed by the Bodie Seeds, Limited, Winnipeg 2, Canada. Promotional literature distributed by Bodie Seeds, Limited, contains reported yields of up to 120 tons of green forage per acre. Quaker Comfrey is propagated by root cuttings. It should be planted on a fertile soil and cultivated to control weed competition. In preliminary palatability studies it was refused by hungry dairy animals and brood sows.

Title: INVESTIGATION OF GENETIC STABILITY IN SEED OF IMPROVED FORAGE CROP VARIETIES

Leaders: C. S. Garrison and R. J. Bula

Studies have been initiated to develop methods for determining the genetic stability of seed of forage crop varieties grown in different areas for one or more generations under varying management practices and harvested from the same field in successive years. Preliminary results, including data on morphological characteristics and disease ratings for Vernal, Rhizoma, Ranger, Narragansett, Grimm, Buffalo, Atlantic, Caliverde, DuPuits, and African alfalfa, and Kenland, Pennscott, Altaswede and Dollard red clover, indicate it is possible to differentiate between these varieties when they are subjected to a specific combination of photoperiod and thermoperiod.

One hundred forty-four (144) seed lots of Ranger, 32 lots of Buffalo, 64 lots of Vernal, 10 lots of Atlantic, 113 lots of Kenland and 5 lots of Dollard produced in various areas and representing breeder, foundation, registered and certified seed, were studied in the field to appraise whether changes were occurring during the seed multiplication processes. Observations of certain morphological characteristics of the Ranger and Buffalo alfalfa seed lots showed that some changes have occurred during the seed increase processes. Critical information is being obtained on the magnitude and the practical implication of these changes.

One hundred forty-three (143) lots of uncertified Ranger alfalfa seed were tested for wilt resistance and growth characteristics under short day length. The wilt data show a range in percentage of plants free of the disease in the different lots from 5.3% to 40.9%.

Twenty-five (25) lots of certified and uncertified S-143 orchardgrass, grown in the United States, were planted to compare their morphological characteristics with breeder seed obtained from the Welsh Plant Breeding Station.

Title: BIRDSFOOT TREFOIL BREEDING

Leaders: P. R. Henson and R. R. Seaney (In cooperation with the Cornell Agricultural Experiment Station)

Initiating this new program over 250 accessions representing 49 Lotus species have been collected. Fifty plants each of 37 introductions have been planted in the field for evaluation. Chromosome numbers have been determined on 25 species. Intraspecific crosses involving 25 species and entailing 141 different crosses and 6500 pollinations have been made. Studies concerned with the inheritance of flower color, seed coat color, hydrogen cyanide reaction, seedling pigmentation, and self-compatibility have been initiated.

Title: CLOVER INVESTIGATIONS

Leaders: E. A. Hollowell, K. W. Kreitlow and R. A. Kilpatrick

More than a million crimson clover plants from domestic and world wide seed sources were subjected under controlled environment to artificial mycelial inoculation of Sclerotinia trifoliorum, the organism causing crown rot disease. Over 30 selfed and polycrossed lines originating from resistant plants have been isolated and subjected to recurrent selection for four generations. When compared with nonselected material under severe artificial inoculation but little progress has been made in increasing resistance. Progeny from greenhouse and field selected Kura clover plants having greater numbers of nodules were better inoculated than the average of unselected plants, indicating that resistance to symbiotic inoculation bacteria might be a factor in failures to obtain inoculation under field conditions, and

that the failures in field inoculation might be overcome through breeding for plants susceptible to the specific bacteria. (Cooperative with Soil Microbiology.)

Healthy and virus-infected genetically identical clonal lines of Ladino white clover were compared for yield and chemical composition. Healthy plants, verified by sub-inoculation of juice to bountiful bean, were cloned into two parts. One clonal line was retained as healthy, the other was inoculated with a mixture of alfalfa and bean yellow mosaic viruses. In greenhouse tests, 320 healthy and 320 virus-infected clonal plants were compared in a compartmented sand-nutrient culture bench. Identical clonal material was compared in replicated field plots 3 x 10 feet containing 120 clonal cuttings per plot. Virus infection in both greenhouse and field tests with several representative clones reduced yield from 23 to 55 percent. Virus infection stunted and reduced lateral spread of most clonal lines tested. Yield of a clone that showed practically no visible symptoms of virus infection was reduced as much as that of clones exhibiting severe virus symptoms. Chemical analyses indicated that healthy clonal material was higher in percent crude fiber while the virus-infected forage was higher in nitrogen-free extract. Stage of maturity at which forage was harvested had a greater influence on percent protein than did virus infection.

Results of pathological studies in cooperation with the New Hampshire Agricultural Experiment Station have indicated that Curvularia trifolii, a fungus causing a leaf disease on white clover, has a wide host range and that white clover plants are susceptible at all stages of growth. Twenty-two (22) white clover plants resistant to this disease have been isolated using a newly developed screening technique. The relative prevalence of fungus associated with disease stolons varies with seasons of the year and geographical locations in New England. In general, the fungus Fusarium oxysporum comprises the highest percentage of isolates.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown, R. A. Peters and E. J. Rubins

(a) Fertilization: In an experiment seeded July 20, 1954, on a soil with pH 5.9, "medium high" in available P, and "very low" in exchangeable K before differential treatments were applied, and with a standard LKB broadcasted on the P area, the first month's top growth of alfalfa was about twice as great in all comparisons where superphosphate (46%) was banded at 90, 180, 360 and 720 pounds per acre as where the same amounts were broadcasted and disked in either 2" or 4" deep (1955 Annual Report, page 35). To answer the question re: the effects of the different rates and placements of P on the stands and yields without any more superphosphate, data were collected in 1955 and 1956. There were no appreciable differences in 1955, but in 1956 stands and yields were somewhat less on the "banded P" plots with the three highest rates of applying superphosphate. In this experiment banding of muriate of potash, ground limestone or ammonium nitrate was of no benefit to either the seedling or the later growth of alfalfa, but high rates of broadcasted potash and limestone resulted in much better stands and yields in the first two harvest years.

Pot Experiment - In a greenhouse pot experiment in which 46 percent superphosphate was mixed with the soil or banded 1" below the seed at rates from 50 to 3200 pounds per acre, the increased seedling growth of both alfalfa roots and tops from banding, decreased with increasing rates until the differences were negligible at the 1600 and 3200 pound rates. In this experiment, also, banding of muriate of potash was not beneficial.

Molybdenum - Field plot and pot experiments are in progress on four different, strongly acid soils to determine the effects of Mo on alfalfa at three levels of liming: none, light and heavy. The preliminary results do not indicate that the addition of Mo has decreased the need for lime.

(b) Varieties: In 1956, the fifth harvest year, all 16 unnamed strains yielded more total dry matter than any of the 14 named varieties. These better yields were correlated with small percentages of wilt infected plants in previous years. Among the 14 named varieties, the wilt resistant ones, Buffalo and Ranger, had much better stands and yields than Atlantic, DuPuits, and Narragansett. This was very evident in the second cutting when Buffalo and Ranger averaged 1500 pounds per acre; Atlantic, DuPuits and Narragansett only 800 pounds.

(c) Management: Buffalo and Rhizoma seedings of 1954 were harvested in 1955 under 10 systems, each system fertilized in four different ways. In contrast to a previous cutting experiment, Buffalo has better stands than Rhizoma, when mowed at an early stage of maturity. It appears that different lots of seed of the same variety give quite different results. Under very liberal NK treatments, cutting at 21, 28 and 35 day intervals killed practically all of the alfalfa in less than one season. The best stands (90%) in 1956 were on plots mowed at 42, 42, and 84 day intervals in 1955. However, nearly as good stands (80-85%) occurred where the periods of growth were 28, 35, 42 and 63 days and also 28, 42, 42 and 56 days. Considerable more harm was done by cutting systems with longer growth periods early in the season but with the third cutting occurring in late August or early September. Fertilization with N or K had little influence on the stands of alfalfa. Where alfalfa thinned, the seeded timothy predominated. Of the 7 cutting systems continued through 1956, 3 yielded practically the same. They were the 42 - 42 - 42, 42 - 42 - 56 and 42 - 42 - 84 day growth period systems or those least frequently mowed in 1955 and 1956.

Title: USE OF HERBICIDES IN FORAGE CROP MANAGEMENT

Leaders: R. A. Peters and B. A. Brown

Seeding of forage legumes in the spring without a small grain companion crop is seldom feasible due to the weed competition which usually results. A number of herbicides were applied post-emergent on legumes in the 2-3 true leaf stage (1955 Annual Report, page 38). The effects of the herbicides on both the weeds and the legume species were determined on the basis of yields from hand separations and from stand counts.

1. Alfalfa yields were greater than in the check when treated with 2,4-DB (2,4-dichlorophenoxybutyric acid amine), Dalapon (sodium dichloropropionate) plus 2,4-DB or Neburon (3,4-dichlorophenyl-1-methyl-1-N-butylurea).

2. Increased yields of birdsfoot trefoil were obtained from the combination of Dalapon plus 2,4-DB or from Neburon. 2,4-DB alone was not effective since it did not control the grasses which proved to be particularly competitive to trefoil.

3. 2,4-DB was not toxic to alfalfa or birdsfoot trefoil up to 3 pounds per acre, acid equivalent.

4. 2,4-DB gave good control of black mustard, ragweed and lambsquarter. This material was only one-third as active as comparable rates of 2,4-D on mustard and lambsquarter.

5. Dalapon alone or with 2,4-DB gave good grass control. Dalapon alone was unsatisfactory since no broadleaf weed control was obtained.

6. Neburon was highly toxic to mustard. It retarded lambsquarter and ragweed but did not give a high degree of kill. The higher rates resulted in grass control.

7. The combination of Dalapon plus 2,4-DB and Neburon treatments had the advantage of being effective on both grass and broadleaf weeds.

8. The results obtained suggest the possibility of making pure seedings in the spring without a companion crop previously considered necessary to subdue weed competition. The greater rate of growth of legumes not subject to companion crop competition would permit greater use of forages the seeding year.

DELAWARE

Title: DIFFERENTIAL IRRIGATION, NITROGEN FERTILIZATION AND THE TOP AND ROOT GROWTH OF SEVERAL FORAGE SPECIES

Leader: W. H. Mitchell

In this study major emphasis will be placed on the following considerations: (1) The effect of depth of wetting of the profile on the distribution of the root systems. (2) The interactions that may exist between depth of wetting and species in relation to root and shoot development. (3) The influence of level of watering on the species response to nitrogen applications. (4) The relationship between level of watering, nitrogen fertilization, and the consumptive use of water by several forage species. (5) The seasonal effect of differential watering and nitrogen fertilization on carbohydrate reserves in the storage organs of each species.

The seedings were made in August of 1956. A split plot design is being employed with species being the main effect. The species involved are alfalfa, Ladino clover, and birdsfoot trefoil, each grown alone and in association with S-37 orchardgrass. Water will be applied when the moisture is reduced to one-half of the total available water holding capacity at the 6", 12", and 24" depths. A fourth water level will consist of normal rainfall only. Fertilizer levels consist of 0 lbs. nitrogen and 200 lbs. of nitrogen per season. Gypsum blocks are placed under the high nitrogen treatment in the straight legume plots and under the high and low nitrogen in the grass - grass and legume plots. The blocks are placed as follows: Ladino clover - 6", 12", 24". Ladino clover - orchardgrass, trefoil - orchardgrass, trefoil, orchardgrass - 6", 12", 24", 36". Alfalfa, alfalfa and orchardgrass - 6", 12", 24", 36", 48", 60". Thermistors are used for soil temperature measurements under the Ladino clover at 1", 6", and 12" depths for all moisture levels in 3 replications. A uniform application of 200 lbs. of P_2O_5 and K_2O will be made annually in a split application. Thirty-two pounds of borax will be applied annually. Ammonium nitrate will serve as the nitrogen

carrier and the nitrogen will be applied in split applications of 50 lbs. each. Root samples will be taken annually following the final harvest of the season as well as samples of the storage organs for determination of the carbohydrate reserves.

Title: BIOLOGY AND CONTROL OF THE CLOVER MITE, BRYOBIA PRAETIOSA KOCH, IN DELAWARE

Leaders: Donald MacCreary, W. A. Connell and C. E. Phillips

The section outlined below deals with the agronomic aspects of this project. Grass plots were established on the University Farm in the fall of 1956. Replicated plots (20' x 20') will receive the following fertilizer treatments per acre:

a.	20 lbs. Nitrogen	March, June, August	(Standard)
b.	40 lbs. Nitrogen	March, June, August	High N
	100 lbs. K_2O	March, June, August	Normal K_2O
c.	20 lbs. Nitrogen	March, June, August	Normal N
	200 lbs. K_2O	March, June, August	High K_2O
d.	40 lbs. Nitrogen	March, June, August	High N
	200 lbs. K_2O	March, June, August	High K_2O

At the time of planting, an 8-16-16 fertilizer was used at 600 pounds per acre. These varied applications should aid in discovering if heavy fertilization is responsible for high reproduction rates in the mite (the fact that all infestations are found in new lawn plantings gives credence to this theory). The legume plantings on the Bunker Hill Project may yield data on this subject as well as on host preferences.

Title: A STUDY OF THE FACTORS INFLUENCING THE PRODUCTION AND MARKETING OF HAY IN NORTHERN DELAWARE

Leaders: W. H. Mitchell, Walter W. Burlin, Ernest N. Scarborough, Clyde Richards and W. T. McAllister

The main objectives of this study are as follows: (1) To determine the influence of planting methods, irrigation and plant nutrients on the growth and development of several forage species. (2) To learn which species or combination of species are desirable for race horse hay. (3) To determine the economic aspects of high quality hay production using several production methods. (4) To further clarify the nature of the demand for high quality horse hay. (5) To determine methods by which hay can be blended to meet the specifications of horse owners. (6) To develop methods of producing and handling artificially cured hay which will substantially reduce the labor requirement.

(7) To determine the influence of drying temperatures on the quality and palatability of hay.

The work is being conducted on a 200 acre tract of land in the vicinity of Middletown, Delaware. The soil is Sassafras silt loam and sandy loam. The study outlined here pertains to an agronomic phase of the project.

Sub-Title: The Influence of Irrigation and Fertilization Treatments on the Growth and Development of Several Forage Mixtures

A split plot design is utilized with forage mixtures the main plot, irrigation the sub-plot and fertilizer treatments the sub-sub-plots. Each mixture is replicated 3 times for a total of approximately 2/3 of an acre in each mixture. The harvested forage will be used for palatability studies with race horses. Yield data will be obtained by the mower strip method.

The forage mixtures being used are as follows: (1) Red clover - commercial timothy, (2) red clover - Climax timothy, (3) red clover - S-37 orchardgrass, (4) red clover - reed canarygrass, (5) red clover - tall fescue (Ky. 31), (6) row plantings of red clover and commercial timothy in 1-1, 1-3, and 3-1 combinations, (7) alfalfa - commercial timothy, (8) alfalfa - S-37 orchardgrass, (9) alfalfa - bromegrass, (10) alfalfa - tall fescue (Ky. 31), (11) alfalfa - reed canarygrass, (12) birdsfoot trefoil (Mansfield) and Climax timothy, (13) red clover (alone), and (14) commercial timothy (alone).

Irrigation levels will consist of (1) natural rainfall and (2) the application of 2" of water when 50% of the available moisture in the 0 to 18" depth of soil has been depleted. With the exception of smooth bromegrass all seed was band seeded using 500 lbs. of 20% superphosphate. Variable annual fertilizer treatments are as follows:

Treatment No.	Lbs. of N	P_2O_5	K_2O	Borax
1	0	0	100	10
2	0	50	100	10
3	0	100	100	10
4	100	100	100	10

MAINE

Title: FORAGE BREEDING AND VARIETY TESTING

Leader: C. R. Blackmon

Red Clover: An excellent stand of red clover persisted into 1956 from the trials planted at Presque Isle in 1955. Yields were taken from both the single-cut and double-cut varieties. The highest yielding single-cut varieties were Alaskan and Leon. Wisconsin Synthetic 32619, Wisconsin Polycross, and Dollard were the leading double-cut varieties. Wisconsin Polycross was superior to other varieties in resistance to northern anthracnose.

White and Alsike Clover: Yield data were taken from the trials seeded in 1955. No significant differences in yields were observed. Persistence will be a big factor in future evaluation.

Alfalfa: Alfalfa clones, polycrosses, synthetics, and varieties were established in 1956 at Orono, under Regional Project N.E. 28. Excellent stands were obtained and two cuttings for yield were taken on the seeded nurseries. DuPuits was the leading variety and compared favorably with the synthetics and polycrosses. In the seeding year, Polycrosses 57-C197, 57-C199, and 57-N.Y. 49-33 were outstanding in performance.

A domestic exploration nursery has been established.

A new variety observational and breeding nursery is planned for 1957.

Title: TIME AND RATE OF NITROGEN ON GRASS

Leaders: C. S. Brown and P. N. Carpenter

Yield and nitrogen recovery data were obtained for the second harvest year from the experiment sown in 1954 (1954 Annual Report, page 29). Orchardgrass maintained a fairly constant yield increase of about 35 lb. dry matter per lb. of N up to the 200-pound nitrogen level. Bromegrass gave a constant response of about 40 lb. dry matter up to the 120-pound nitrogen level, declining rapidly above this. Timothy showed a gradual decline in response to each increment of nitrogen, starting at about 50 lb. dry matter at the 40-pound level and declining to 20 lb. dry matter at the 200-pound level. Orchardgrass was the only species to respond markedly above the 200-pound nitrogen level. The respective dry matter yields with 200 and 360 pounds nitrogen were: timothy 7000 and 7600; bromegrass 7550 and 7780; orchardgrass 7410 and 9250. Apparent recovery with applied nitrogen ranged from 60% to 80%. Grasses receiving no nitrogen yielded 20 lb. N per acre. Mixtures of Ladino clover-grass receiving no nitrogen produced 137 lb. N. Plots receiving 360 pounds of nitrogen, split-applied, produced 234 lb. N.

Title: TIME AND RATE OF NITROGEN ON LEGUME-GRASS

Leader: C. S. Brown

Plots of Ladino clover-timothy and trefoil-timothy (Viking trefoil) were established in July 1955. Excellent establishment of the legumes was obtained, but relatively poor timothy stands were established in the Ladino clover. Differential nitrogen and cutting treatments were begun in 1956. A comparison of an early hay or silage cut on June 15 to a late hay cut on July 15 was made with all nitrogen treatments. All plots were managed as simulated pasture after the first cut. The nitrogen treatments, involving differential rates of nitrogen in April and July, were as follows: 0-0, 30-0, 60-0, 0-60, and 60-60. No important effects of the nitrogen were observed with the Ladino clover-timothy, apparently because of the dominance of Ladino in the stands. Cutting date in the spring had a marked effect upon botanical composition by September. Botanical separations of the September cut showed 82% Ladino in the plots first cut in June, and 34% in the plots cut in July. Nitrogen had a marked effect upon yield and botanical composition of the trefoil-timothy. Total yield was increased and trefoil percentage reduced by the higher rates of nitrogen. Nitrogen applied in July resulted in less repression of trefoil than spring nitrogen and gave higher total yields. Hand separations of the September cut showed the following dry matter yields of the trefoil fraction from the late-cut series: 1260 lb. with the 0-0 nitrogen treatment, 860 lb. with 0-60, 630 with 30-0, 460 with 60-0, 380 with 60-60. Differences were smaller within the early-cut series.

Title: GRASS SILAGE PRESERVATION

Leader: H. C. Dickey

Using small experimental silos of 7-ton capacity, a comparison was made of unwilted silage (78% moisture) with 150 pounds of dried potato pulp per ton vs. wilted silage (65% moisture) with one pound of "SILO JOY" per ton. The latter is a commercial product developed to improve silage flavor. Input-output data have not as yet been completely evaluated. Feeding trials were conducted with yearling dairy heifers for 75 days. Feed preference was indicated for the wetter silage receiving the potato pulp.

MARYLAND

Title: VARIETY AND STRAIN TESTING OF FORAGE LEGUMES AND GRASSES

Leader: A. Morris Decker, Jr.

Alfalfa: Sockeville and DuPuits were the highest producing varieties at College Park in 1956. These were followed by Narragansett, Williamsburg, and Atlantic, in that order, with Vernal being substantially lower in production than any one of these varieties.

Red Clover: Stevens, a local strain to be released by the Maryland Agricultural Experiment Station under the name of Chesapeake, continues to be outstanding in all variety trials throughout the State. Pennscott continues to be as good or better than Kenland in central and western Maryland and decidedly better than Kenland in the eastern part of the State. Several new local strains look promising.

Sudangrass, Pearl Millet and Sorghum: Hybrid #1 pearl millet, common pearl millet, Piper sudangrass, U.S. 505 corn and thirteen sorghums were tested at three locations for silage production. One location was on the Eastern Shore and the other two locations were in the College Park area. All entries were seeded in 40-inch rows. On the Eastern Shore, Hybrid #1 millet and Sumac 1712 sorghum gave the highest yields, followed by Honey Sorgo Oklahoma, Atlas sorghum, U.S. 505 corn, Hegari sorghum, Rox Orange sorghum, common pearl millet and then Piper sudangrass. The pattern was somewhat different in the College Park area with Sugar Drip, Kansas Orange and Honey Sorgo producing the highest silage yields. U.S. 505 was only slightly lower in production followed by Atlas sorghum Hybrid #J. millet and Piper sudangrass. The sorghums were, in general, low in protein. The millets were generally higher in both protein and fiber than other entries in the test.

Orchardgrass and Tall Fescue: Kentucky 31 fescue was somewhat higher in production than Alta fescue. Both fescues were superior to the orchardgrass entries tested. Commercial orchardgrass and Potomac orchardgrass produced similarly, while the late maturing orchardgrasses were lower in production. Ladino clover was grown with each entry.

Bermudagrass: Five Bermudagrass strains were established at three locations in the potential Bermudagrass area of the State. Good stands were obtained at all locations. Stands were clipped for weed control, but no yields were taken in 1956. It is too early to determine the extent of winter injury of the less winter hardy varieties. As a result of observational notes taken during the 1956 growing season, Midland appears most promising. However, the Greenfield variety looks good on the heavier soils.

Title: LADINO CLOVER BREEDING

Leader: A. Morris Decker, Jr.

Clonal evaluations of some of the better appearing clones were continued (1955 Annual Report, page 44). Ten clones selected at the U. S. Regional Pasture Research Laboratory, six clones selected at Maryland, and four parental clones of Pilgrim Ladino clover were set out in a screenhouse in the spring of 1956. Each clone was replicated six times. Honey-bees were used as pollinators. Two harvests of polycross seed were made. Seed production varied from 0.02 grams up to 54.30 grams. Thirteen of these clones produced sufficient seed to be progeny tested at Maryland, New Hampshire, and the Pasture Laboratory. These seedings are being made in the spring of 1957.

Title: IMPROVEMENT OF RED CLOVER ADAPTED TO MARYLAND

Leader: A. Morris Decker, Jr.

Four related lines which have been subjected to repeated seedling inoculation of southern anthracnose (Colletotricum trifolii) and which show a high degree of perennialism were each isolated and seed harvests made. Topcross seed was also collected between each of these four lines and a 50-50 mixture of Stevens and Reinhold red clover (two superior local strains). Sufficient seed was obtained in each case to make forage evaluations and stand longevity determinations. These plots were seeded in the spring of 1957. As a result of intensive testing each year of named varieties and many local strains, excellent breeding material has been obtained. Breeder seed of the Stevens strain, one of the leading clovers for the past ten years, has been sent to California for seed increase and will be released as a new variety "Chesapeake". Seed should be available for 1958 seedings.

Title: ORCHARDGRASS BREEDING

Leader: A. Morris Decker, Jr.

Evaluations of approximately 3,000 spaced plant progenies (1955 Annual Report, page 45) were continued. Wide differences in leafiness, leaf distribution and coarseness were observed. Tests of varieties and experimental synthetics in several locations in the State were continued.

Title: NITROGEN FERTILIZATION ON PURE GRASS AND GRASS-LEGUME ASSOCIATIONS

Leader: A. Morris Decker, Jr.

Six grasses grown alone and with a legume under three levels of nitrogen fertilization were harvested for the second growing season (1955 Annual Report, page 47). Total weed-free forage yields ranged from 1.20 tons per acre to 5.23 tons per acre. The location of this study was on a light sandy soil with low water holding capacity which is classified as Adelphia fine sandy loam. In this study it was difficult to maintain adequate legume stands and, in general, production was much higher and more uniform where nitrogen was supplied by commercial fertilizer rather than by the associated legume. From these limited results, it seemed that forage production on such soils could be maintained more economically through the use of commercial nitrogen than by attempts to maintain legume stands.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leader: A. Morris Decker, Jr.

Kentucky bluegrass-timothy-white clover, orchardgrass-Ladino clover-red clover, reed canarygrass-Ladino clover-red clover, and Midland Bermudagrass-crimson clover pastures (1955 Annual Report, page 47) were evaluated for beef production using yearling Hereford steers. Beef production per acre was highest for Bermudagrass followed by orchardgrass, reed canarygrass and then Kentucky bluegrass. Beef production and carrying capacities of Bermudagrass were nearly three times as large as the other three mixtures during the late summer months. Only in the early spring were these mixtures superior to Bermudagrass. Rye and crimson clover were seeded in the Bermudagrass paddocks in the fall of 1956 to see what could be done to extend fall grazing and increase early spring production.

MASSACHUSETTS

Title: SOURCES OF FERTILIZER PHOSPHORUS FOR FORAGE CROPS: SUPERPHOSPHATE VS. GROUND RAW ROCK PHOSPHATE

Leaders: J. E. Steckel and Mack Drake

This project was described in the 1951 Annual Report, pages 45-49 and again reported in the 1953 Annual Report, pages 33-35.

Five year dry matter forage yields from plots variously treated with phosphate fertilizers (lbs./acre). Experiment located on a Loessial soil near Amherst, Massachusetts.

Treatment	Timothy	Alfalfa	Ladino-Brome
1000 super 20%	40,490	35,850	24,990
2000 super 20%	41,430	37,240	27,100
2000 rock 34%	40,580	36,990	24,330
2000 rock 34% 100 sulfur	39,840	35,430	25,560
2000 rock 34% 456 sulfur	40,760	36,710	26,190
3000 rock 34% 100 sulfur	40,800	36,770	25,600
4000 rock 34% 100 sulfur	42,320	38,390	25,230
500 super 20% 1000 rock 34%	43,240	37,310	25,840

When the above data were treated statistically, there was no significant difference due to treatment. These results are interesting in that other Stations in the Northeast have reported that rock phosphate was a poor source of phosphorus for perennial forage plants.

To explain these discrepancies we offer the following suggestions:

1. Rate of application - Admittedly rock phosphate does not supply much soluble phosphate immediately after application. Hence when rock phosphate alone is used, a heavy rate of application must be used prior to seeding to supply enough readily available phosphate to get the seedling plants off to a good start. If there is not enough readily available phosphorus in the soil at seeding time, the new seedlings get off to a poor, slow start and subsequent yields of forage are adversely affected. The high rate of rock phosphate in this experiment should be noted.

2. Response to rock phosphate by soils with high phosphate fixing capacity - With some soils, even high rates of rock phosphate application do not give satisfactory results. If a smaller application of a readily available source of phosphate such as superphosphate is used in conjunction with raw rock, good results are obtained. We interpret these responses to mean that once seedling plants have established a well developed root system, they can satisfy their phosphorus needs from relatively insoluble forms of soil phosphate including rock phosphate and also iron and aluminum phosphates. We believe that the presence of relatively large quantities of chelating organic substances in the root environment of perennial forage species explains why these crops are able to utilize relatively unavailable forms of soil phosphates. If ground rock phosphate is used as a source of phosphorus for perennial forage crops, it would seem desirable to employ a combination of superphosphate with raw rock phosphate to insure good seedling establishment and vigorous seedling growth.

Title: NITROGEN RATE AS AFFECTING CALCIUM AND POTASSIUM CONTENT OF ALFALFA AND ORCHARDGRASS

Leaders: M. Drake and J. White

For the past three years a mixture of orchardgrass and alfalfa has received three levels of N and K. The effect upon the Ca and K content of the individual species is illustrated in the table with data from the third cutting of the third year.

Calcium and potassium content of the dry matter of alfalfa and orchardgrass grown in association.

*Fertilizers, lbs./acre/yr.		Orchardgrass		Alfalfa	
K_2O	N	% Ca	% K	% Ca	% K
67	0	0.22	3.60	0.98	1.86
67	125	0.24	3.35	1.12	1.61
67	250	0.25	3.15	1.05	1.70
184	0	0.21	3.78	0.90	2:19
184	125	0.20	3.60	1.01	1.98
184	250	0.21	3.85	1.02	1.94
300	0	0.18	3.93	0.90	2.36
300	125	0.18	4.00	0.80	2.29
300	250	0.16	4.03	0.89	2.16

*K_2O applied as 0-50-100 lbs. before cut, 33-67-100 lbs. after first and second cuts.

N applied as 0-50-100 lbs. before and after first cut, 0-25-50 lbs. after second cut.

Nitrogen depressed K content of orchardgrass at the lowest level of K, and increased Ca content slightly. This suggests that nitrogen increased root cation exchange capacity, resulting in increased uptake of Ca and decreased uptake of K. At medium and high levels of applied K, no consistent effect upon mineral content was observed. The effect of increased nitrogen fertilization upon Ca content was further shown with pure stands of orchardgrass. The application of 50 and 100 pounds N per acre after the first cut resulted in Ca content of 0.30 and 0.41 percent, respectively. As shown in the table, an increasing rate of applied K resulted in increased K content and decreased Ca content of both orchardgrass and alfalfa.

NEW HAMPSHIRE

Title: IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick (In cooperation with Forage and Range Section, A.R.S., U.S.D.A.)

Surveys of diseases attacking white clovers in New England have shown that at least 8 diseases are prevalent throughout the growing season. The extent of injury depends, primarily, on weather conditions, although management and varieties also affect the disease development.

Greenhouse inoculations of Curvularia trifolii have been made on 36 species of Trifolium. All are susceptible, although there is a wide range of susceptibility. Previous to these studies only 6 species of Trifolium had been reported as being susceptible. In addition, 2 new hosts, Medicago sativa and Ebenus cretica were found to be susceptible. White clover plants were found to be susceptible at all ages. White clover seedlings from approximately 70 different sources, comprising 5,000 plants, have been screened for Curvularia leaf spot reaction in the greenhouse. Approximately 18 plants have been selected for resistance. These plants are being vegetatively increased for production of seed next spring.

Isolations have been made from rotted stolons of white clover obtained from various locations in New England. The most commonly isolated fungi consist of the Fusaria group, although numerous others also have been obtained. Observations suggest that the primary injury may be due to unknown factors, such as scalding, burning or desiccation, with fungi coming in secondarily. Greenhouse inoculations are under way. Results are incomplete at this time.

Solid plots of the 4 types, Wisconsin White Clover, Pilgrim, Oregon Certified and Vermont Polyploid, were established at 2 locations. The chief purpose of this experiment is to study development and survival of the taproot, and causal organisms associated with taproot rotting. A number of these plots will be caged in 1957 to prevent natural reseeding. Several samples were taken of these seedling plants in the fall of 1956. Taproots of Wisconsin white clover were very small in comparison to those of Pilgrim, Oregon Certified, and Vermont Polyploid. Plants of Wisconsin white were very susceptible to rotting of the taproot. Rotting of the root system was confined largely to the fibrous roots. Fusarium oxysporum was the most common isolate obtained. These seedling plants ranged from 6 to 18 weeks of age. There appears to be a progressive increase in the amount of root rot correlated with age of plants. Further observations will be made in 1957.

During the winter of 1955-56, the same 4 strains of white clover were studied for seedling growth and development in the greenhouse. Results again indicated that the polyploid Ladino develops very slowly as a seedling, has significantly fewer stolons than other types, but generally is considerably larger in stolon and petiole diameter, leaflet size, etc. White clover initiated stolons faster, has a larger number of stolons, and elongation, at least in the greenhouse, is faster than that of Ladino types. Initiation of stolons in the field also appears to be most rapid with white clover and slowest with polyploid Ladino.

The root system developed in the greenhouse was largely fibrous with a very small taproot. It was observed that root rot had eliminated the taproot of numerous Wisconsin white clover plants after 5 or 6 months of growth in the greenhouse.

These plants were transferred to the field, a wire was placed by the taproot, and 2 stolon cuttings made of each plant. It is planned to study growth characteristics, causal organisms associated with death of the taproot, and the relation between seedling characteristics and survival.

Twenty-four Ladino clones selected for persistence were transferred to field plots for production of polycross seed under cages in 1957.

A new source nursery of approximately 1,400 plants was established in 1956. Many of these were open-pollinated progenies from plants selected at New Hampshire for persistence. Plants in this nursery were spaced 5 x 5 feet and over-seeded with timothy in the fall of 1956.

Yield data were obtained on 11 white clover seed lots which were seeded in 1955. Small differences were obtained between Ladino sources, except for polyploid Ladino which was lower in yield than the others. New Zealand white clover performed very poorly and appeared to be unable to compete with bromegrass in a mixture. An additional yield test was established in northern New Hampshire.

About 30 Trifolium species were established as spaced plants in the field, and some data obtained on their self-fertility.

Two growth chambers with controlled light, temperature and humidity are nearing completion. A freezing room is also being constructed to study the effect of low temperatures and diseases on survival.

Title: IMPROVEMENT OF SMOOTH BROMEGRASS, RED CLOVER AND ALFALFA

Leaders: Gerald M. Dunn and Leroy J. Higgins

A positive correlation was found in bromegrass between self-fertility in the field and cross-fertility in the greenhouse. Crossing was by open-pollination of emasculated female parents (1955 Annual Report, page 48). This method was more effective than bagging panicles of the two parents. Increased seed set was obtained by spraying the female plants with a fine mist of water at flowering.

Artificial inoculation studies were continued with P. bromi. Reasonably good infection was obtained in the greenhouse on bromegrass seedlings and clones by inoculation with agar cultures. In the field, the primary epidemic in the spring of 1956 was approximately three weeks later than the two previous seasons. In 1956, lesions were not visible until about May 11. The spring of 1956 was unusually late at Durham. Artificial inoculation in August, 1956, with infected leaf material was relatively ineffective compared to the two previous seasons. Although a heavy natural infection usually is present in September at this location, there was very little infection on any plants in the fall of 1956. August and early September were unusually dry. Natural infection was heavy, however, in the spring and during the cool month of July on plants which were cut early in June. These results indicate that climate and management have a great influence on incidence of brown spot. A polycross nursery was established of 144 selections made primarily on the basis of brown spot resistance and good recovery.

Nurseries were established of S_1 lines to compare effectiveness of selection for brown spot resistance in inbred vs. open-pollinated lines and to determine the reduction in vigor under self-pollination. In general, vigor characteristics such as height and spread were reduced 30-40 percent in the S_1 generation compared to open-pollinated lines from the same parental clone, although a few inbred lines were quite vigorous. A number of vigorous S_1 plants were selfed to obtain S_2 progenies. Very little information was obtained on the resistance of inbred vs. open-pollinated lines since artificial inoculation was not effective in the field in 1956.

Yield data were obtained for 10 bromegrass varieties at Colebrook for the fourth season. Fischer yielded about 500 pounds more dry matter than any other variety for the 4-year period. Two northern types, Parkland and Canadian commercial, yielded as well as the other 7 southern varieties at this location.

An alfalfa variety trial was established in 1956 at Colebrook, New Hampshire.

More breeder seed was obtained by crossing one to six-year old potted New Hampshire red clover plants in the greenhouse. Replicated variety trial plots were established in July, 1956, using Dollard, Kenland, La Salle, New Hampshire, Pennscott, Redon, Stevens and Wisconsin-53. A small increase plot of New Hampshire red clover also was established.

Title: WATER AND FERTILIZER REQUIREMENTS OF SELECTED CROPS AND SOILS AS RELATED TO SUPPLEMENTAL IRRIGATION

Leaders: A. B. Prince, P. T. Blood and R. S. Palmer

Plots were established in the summer of 1955 to determine the rates of irrigation and fertilization required for economic production of bromegrass (Achenbach) and Ladino clover (Pilgrim). Yields of bromegrass were affected significantly not only by N topdressing but also by irrigation during the latter part of the season. No significant interaction between N topdressing rate and irrigation rate was indicated by statistical analysis. Total yields of four clippings for the season varied from 4138 pounds dry matter per acre where no N or irrigation water were applied to 7783 pounds where 160 lbs. of N topdressing and 7.5 acre-inches of irrigation were applied. There was no residual effect on yield of N from one topdressing to the next. The results indicate that both frequent N topdressing and irrigation were needed to maintain fairly uniform production of forage and protein throughout the season.

Variation of the rate of K and Mg topdressing did not affect significantly the yields of a bromegrass-Ladino clover mixture. The total yield varied from 6722 to 8654 lbs. dry matter per acre. Total yields were increased as the result of a response to irrigation in the fourth clipping. The proportion of bromegrass in the mixture was highest in the first clipping (85%) and rapidly decreased in succeeding clippings until it was generally less than 10% in the fourth clipping.

Title: THE EFFECT OF SOIL TYPE AND MINERAL ADDITIONS ON THE MINERAL CONTENT OF TIMOTHY AND CLOVER

Leaders: G. P. Percival and D. Josselyn with cooperation of K. C. Beeson, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York

Results from studies carried out in the greenhouse in 1955 showed that the addition of single treatments of Fe, Mn, Zn and Cu at the rate of 30, 60 and 90 pounds of chelated compounds per acre did not overcome the depressing effect of lime on the yields of oats on a Paxton soil. Chemical analyses of the oat plants showed that lime had a depressing effect on the uptake of the minor elements when compared to the unlimed soil, especially on manganese content which decreased from 312 to 18 ppm. Ninety pounds of manganese chelate did result in some increase in Mn content recovery as compared to the lime treatment.

Yields of oat plants grown in the greenhouse in the winter of 1956-57 showed that with the absence of lime there was a significant increase of growth due to the addition of zinc both as the chelate and as the sulfate. Similarly, copper caused significant increases in yields as a chelate, as the sulfate and as the oxide. The lowest application of copper chloride caused a significant increase in yield, but higher applications resulted in a decrease. The addition of lime overcame the detrimental effect on yield of the higher applications.

Title: THE EFFECT OF HEAVY FERTILIZATION OF THE SOIL ON THE MINERAL CONTENT OF FORAGE AND THE EFFECTS OF FEEDING SUCH FORAGES TO DAIRY CATTLE

Leaders: H. A. Keener, F. E. Allen, H. A. Davis, K. S. Morrow and G. P. Percival, with cooperation of K. C. Beeson and E. J. Thacker, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York, and K. McEntee, Cornell Veterinary College, Ithaca, New York

Deficiencies in forage produced by growing it under conditions of heavy fertilization of the soil are being investigated further (1955 Annual Report, page 50). It appears that mineral supplements are not effective in relieving deficiency symptoms until a deficiency of some unidentified organic factor has been corrected. Further work is being carried out to clarify the problem.

Title: CAUSES OF REPRODUCTIVE FAILURE IN CATTLE FED LADINO CLOVER MIXTURES

Leaders: H. A. Keener, F. E. Allen, Ann C. Paul, K. S. Morrow and H. A. Davis

Work carried out previously at this station has indicated that cows fed Ladino clover-bromegrass hay produced under conditions of heavy fertilization of the soil have required significantly more services per conception than cows fed timothy hay produced under comparable conditions. A new study of this problem has been initiated. The effects of level of fertilization and mineral supplementation of the ration are included in the study. Results are not available as yet.

Title: ERRORS IN DRYING SILAGE AND FECES FOR PROTEIN AND ENERGY DETERMINATIONS. IMPROVED PROCEDURES

Leaders: N. F. Colovos, H. A. Keener and H. A. Davis

Silages lost from 0 to 37 percent of their protein content when dried for analysis. Grass silages preserved with molasses, sulfur dioxide and sodium metabisulfite retained their crude protein content much better than corn or unpreserved grass silage. Energy losses due to drying ranged from 9 to 19 percent with the values for different types of silages averaging between 11 and 14 percent. Similar losses of protein and energy were found to occur when feces were dried. It was concluded that both protein and energy should be determined on fresh feces and silage. Gross energy can be determined successfully if 95% ethyl alcohol is used as a primer.

NEW JERSEY

Title: EVALUATION OF FORAGE STRAINS AND VARIETIES

Leaders: W. R. Battle, R. A. Cappellini, R. S. Filmer and M. T. Hutchinson

Fifteen varieties of alfalfa were continued under test at three locations. Summarization of three years' data showed significant differences between varieties with Atlantic, Vernal, DuPuits and Narragansett being outstanding in yield. Narragansett and DuPuits proved highly susceptible to bacterial wilt and accordingly are not recommended for this State. Vernal proved superior to Buffalo, and has been placed on the recommended list in place of Buffalo.

Tests of eleven varieties of red clover showed Pennscott and Stevens (renamed Chesapeake) to be superior to all others. Pennscott is retained on the recommended list, and Chesapeake will be added if an additional year's data bear out the earlier findings.

Title: GENETICS AND BREEDING OF FORAGE LEGUMES

Leaders: W. R. Battle and W. Jurgelsky, Jr.

Studies of protein and carotene content of alfalfa clones demonstrated large differences between clones for these constituents. Increased amounts of one constituent were associated with increased amounts of the other. Amounts of protein and carotene varied between harvests and between seasons, but in general, the clones maintained their relative rankings. Two high ranking and two low ranking clones were inbred and were crossed in all combinations. The inbred and F_1 progenies were grown to maturity in the greenhouse, harvested twice, and are being analyzed for protein and carotene content. Results of the studies will be used to estimate the degree and type of inheritance involved.

Poor seed setting conditions prevented harvest of seed from individual lines of the wilt-resistant Atlantic material. A bulk lot of polycrossed seed was harvested and will be retained for comparison with individual lots to be harvested from the 280 lines this season.

Title: YIELD AND PROTEIN CONTENT OF GRASSES WHEN FERTILIZED WITH HEAVY RATES OF NITROGEN

Leaders: C. H. Ramage and C. Eby

Grasses used were orchardgrass and reed canarygrass. Since the application of only 100 pounds of K_2O to orchardgrass in conjunction with heavy rates of nitrogen fertilizer resulted in a potassium deficiency in 1955 (the third continuous year of such treatment), 300 pounds of K_2O were applied to the grasses to correct the deficiency. Yields of dry matter, the percentage of protein, and the pounds of protein per acre during 1956 were as follows:

	0# N	50# N	100# N	200# N	400# N	600# N
			ORCHARDGRASS			
D.M., lbs./acre	3496	4233	4649	7070	8267	9120
Protein, %	12.52	12.55	12.17	14.61	18.55	20.58
Protein, lbs./acre	439	535	569	1077	1610	1877
% N recovery	—	30.72	20.80	51.00	46.75	38.33
			REED CANARYGRASS			
D.M., lb./acre	3633	4505	5097	7868	9874	10,868
Protein, %	13.14	13.44	13.30	14.87	18.47	20.27
Protein, lbs./acre	478	615	676	1202	1947	2229
% N recovery	—	43.84	31.68	57.92	58.76	46.69

Title: THE EFFECT OF N AND K APPLICATIONS AND FREQUENCY OF CUTTING UPON YIELD OF ATLANTIC ALFALFA IN NEW JERSEY

Leader: E. R. Purvis

For the fourth season, (1955 Annual Report, page 54), application of 200 pounds of N per acre resulted in an increase in dry weight yield of approximately 1 ton per acre, and an increase in protein yield of approximately 600 pounds per acre, when the alfalfa was cut 4 times in pre-bloom stage. Yield increases due to N treatment were not obtained when the crop was harvested 3 times in one-tenth-bloom stage. Harvesting 4 times resulted in removal of more K than applied on plots receiving 300 pounds of K_2O per acre.

Title: EFFECT OF PLANT FOOD COMBINATIONS ON ALFALFA

Leader: G. H. Ahlgren

This study is now in its fourth year in which data have been collected (1955 Annual Report, page 54).

In the nitrogen phase of this study the basic treatment was 0-10-20 fertilizer. Nitrogen was added at 25, 50, 100, and 200 pounds per acre. Yields were as follows: at 25 lbs. N, 3.17 tons per acre; at 50 lbs. N, 3.41 tons; at 100 lbs. N, 3.26 tons; at 200 lbs. N, 3.15 tons per acre. It is doubtful that any of these yields are significantly different, indicating that it probably does not pay to add nitrogen to alfalfa at least on the three cutting system used.

The phosphorus applications at 0, 50, 100, 200 and 400 pounds per acre show no significant response in yields. These ranged from 3.33 tons per acre with no phosphorus added to 3.64 tons per acre with 50 pounds of P_2O_5. Other yields were intermediate. This lack of response to phosphorus can only mean that the soil is releasing the needed amounts for full growth and response of the crop. Early soil tests indicated a medium to low phosphate content.

A strong response to potassium continues to be found. Rates of potash used and yield response are as follows: no potash, 1.43 tons per acre; 50 lbs. K_2O, 2.74 tons per acre; 100 lbs. K_2O, 3.65 tons per acre; 200 lbs. K_2O, 4.00 tons per acre; and 400 lbs. K_2O, 3.67 tons per acre. The most economic yields appear to be obtained with approximately 200 lbs. of potash per acre per year.

The addition of molybdenum and of boron either alone or in combination gave no better yield responses than a no-treatment-plot series.

Title: EFFECT OF TIME OF FERTILIZING ALFALFA

Leader: G. H. Ahlgren

No difference in response of alfalfa has been found in time of fertilizing (1955 Annual Report, page 55). Treatments studied were, all fertilizer added in the spring, after the first cutting, or after the last. Also half of the fertilizer was applied in the spring and half after the first cutting, in the spring and after the last cutting, and after the first cutting and after the last cutting. Further, the fertilizer was divided into three equal amounts, one-third applied in the spring, one-third after the first cutting, and one-third after the last cutting. The total fertilizer added was 1000 pounds per acre of 0-10-20 for each treatment. Yields varied from 3.57 tons per acre to 3.95 tons per acre and none was significantly greater than any other.

Title: PRESERVATION OF SURPLUS SPRING PASTURAGE IN PLASTIC MATERIALS AS SILAGE

Leaders: M. A. Sprague, C. H. Reed and W. L. Larrabee

The efficient preservation of excess pasturage during the flush production period of early spring would aid farm enterprises greatly. Similarly timely removal of the forage from the pasture would aid materially in pasture management and maintain production at a more consistently high level throughout the remainder of the season.

Experimental silos containing 10 to 15 tons covered with polyvinylchloride film have given consistently high efficiency in the preservation of forage nutrients (1955 Annual Report, page 60). Three such units preserved with molasses showed total dry matter losses of only 4.3, 4.6 and 8.2%. Surface spoilage was zero where air-tight conditions were maintained. Fifteen farm installations varying from 25 to 75 tons capacity bore out these findings as practical for use on farms. Similar use of plastic materials as caps on tower silos has eliminated surface spoilage easily and economically.

Title: PASTURE RENOVATION STUDIES

Leaders: M. A. Sprague, R. J. Aldrich and T. O. Evrard

During 1956 data were collected from several experiments both in the field and greenhouse. Dalapon at 4 lbs. and amino traizle at 1 lb. were observed to function effectively for renovation under carefully considered conditions of the sod. Sods which were very closely grazed and in an active state of growth experienced 100% kill under this treatment. However, under conditions of under-grazing where material accumulations of topgrowth remained on the surface, kill was inadequate at these rates. A better chemical or

method of use is needed for this purpose. Numerous trials were put on farms in 3 to 10 acre trials. In Sussex County two 4-acre fields of 15 to 20% slopes were used to compare a plowed seedbed with chemical renovation. Rye and bromegrass were first seeded in the fall, the clovers seeded on frozen ground in March and the rye was grazed twice in the spring. In a late summer grazing, the plowed area yielded 707 lbs. per acre of forage consisting of weeds (50%), clover (35%) and grass (15%). The renovated field yielded 1493 lbs. per acre of seeded legumes (80%), grasses (15%) and weeds (5%). The difference between these two 4-acre pastures was due mostly to severe erosion on the plowed area and nearly complete erosion control on the renovated pasture. In Somerset County 4 acres of sod were seeded to rye, bromegrass and clover in September 1956. On another farm 6 acres were treated and seeded to rye, legumes and grasses. In Burlington County 10 acres were seeded to barley, bromegrass and alfalfa. All experienced an excellent kill from amino triazole-Dalapon treatments, established themselves well in fall on seedbeds disked either two or three times, were grazed in the fall and the clover seeded in February. The fall treatment with fall seeding of small grains and grass and spring seeding of legumes has given consistently good seedling establishment.

Greenhouse studies have been initiated to determine the effects of nitrogen and frequency of clipping applications upon the susceptibility of bluegrass sods to promising herbicides.

Title: HORSE PASTURE RESEARCH

Leaders: R. W. Duell, M. A. Sprague and R. Marrese

With ample rainfall during the past growing season, differential fertilization of six commonly used pasture grasses did not maintain the corresponding differential yields to the end of the season as they had in previous dry years (1955 Annual Report, page 58). Kentucky bluegrass yielded well during the season with good rainfall distribution. Bromegrass and timothy yielded poorly at the last (4th) cutting.

In sudangrass and millet variety trials the millets were again high yielding at the time of the first cutting but yielded poorly or made no regrowth thereafter. Yields of sudangrass were increased considerably by a topdressing of 25 lbs. N from NH_4NO_3 after the first cutting and this treatment had a highly significant effect even on the third cutting. Wheeler sudangrass again was the highest yielder under pasture management and this variety was not excessively high in HCN content when cut at 18 inches.

Midland Bermudagrass proved sufficiently winter-hardy in New Brunswick and locations in the southern part of the state. Plantings of this grass were established to conduct fertilization studies.

Burnet, Nebraska 50 wheatgrass and Nordan wheatgrass appear promising as cool season pasture species, for their color retention and rate of growth under these conditions surpass those of our more common pasture grasses.

Title: THE FEEDING VALUE OF HIGH NITROGEN GRASS PRODUCED BY HEAVY NITROGEN FERTILIZATION

Leaders: C. H. Ramage, C. Eby, R. E. Mather and E. F. Ogrinz

A double reversal feeding trial is being conducted to compare the feeding value for milk production of alfalfa hay (18% protein), high protein orchardgrass hay (15% protein), and low protein orchardgrass hay (12.5% protein).

At the conclusion of the second period of the trial, milk production and consumption of forage to date have been as follows:

	Low N hay	High N hay	Alfalfa hay
Pounds of 4% FCM per day	28.38	32.56	33.47
Pounds of hay equiv. consumed per day per 100# body wt.	2.03	2.15	2.40

A preliminary statistical analysis of the data for the high nitrogen orchardgrass-alfalfa comparison indicated that the difference in milk production was not significant.

NEW YORK (CORNELL UNIVERSITY)

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS WITH THE FORAGE PLANTS OF NEW YORK

Leaders: R. P. Murphy, R. E. Anderson, C. C. Lowe and J. W. Miller

Studies are in progress with alfalfa, birdsfoot trefoil, smooth bromegrass, timothy, and orchardgrass (1955 Annual Report, page 60).

About 500 new clones of alfalfa have been selected for clonal evaluation and progeny testing. These clones have been selected from seedling nurseries which were concerned with studies on common leaf-spot resistance, leaf-hopper tolerance, bacterial wilt resistance, and combining ability. The second cycle of selection for the creeping-rooted characteristic is being evaluated in the field. The second and third backcrosses for the addition of bacterial wilt resistance to Narragansett and to Flemish types are under way. Studies on the inheritance of self-incompatibility in diploid alfalfa species have given no clear cut patterns of inheritance.

A new group of selected clones of bromegrass is being progeny tested. The selected clones have come primarily from the best synthetics and the polycross progeny of the best clones from the first cycle of selection. The studies on the cytology of selected clones and on open-pollinated fertility gave rise to several tentative conclusions: 1. open-pollinated fertility was a highly heritable character; 2. stainable (carmine) pollen showed no apparent association with open-pollinated fertility; 3. aneuploidy showed only a slight positive association with open-pollinated fertility; 4. accessory chromosomes or fragments were found in about one-third of the clones studied; and 5. about one-half of the clones studied had 56 chromosomes and the others had 54, 55, 57 or 58.

A new group of selected clones from the second cycle of selection has been planted for polycross seed production for timothy and orchardgrass. A number of promising clones which are later in maturity and much leafier than common sorts has been selected. It appears that the second cycle of selection has shown a relatively larger degree of improvement with these two grass species than with bromegrass.

Studies have been initiated with artificially produced tetraploids of big trefoil (*Lotus uliginosus*) and narrowleaf trefoil (*L. corniculatus* var. *tenuifolius*).

Seedlings from self-pollination and open-pollination of first generation plants grown from fast-neutron-irradiated seed of bromegrass, timothy, orchardgrass and alfalfa have been established in the field. Very few abnormal seedlings have been noted.

Title: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST. SUBPROJECT I: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO NEW YORK AND ADJACENT AREAS OF THE NORTHEAST

Leaders: C. C. Lowe, R. P. Murphy, R. E. Anderson, A. A. Johnson, F. C. Bent and H. A. MacDonald (Agronomy) cooperating

The alfalfa polycross test at Ithaca was concluded; results are being summarized regionally along with concurrent tests at other stations (1955 Annual Report, page 62). Differential persistence of progenies was quite evident in the fifth year of testing. The polycross test at Canton, New York was continued for evaluation under more northern conditions.

Detailed summaries and analyses of results were completed on the study of performance of syn.-1, syn.-2, syn.-3 and syn.-4 seed generations of alfalfa synthetics. Tentative conclusions indicate that there is a decline in performance between the first and advanced generations. The study indicated that in comparing the performance of synthetics with existing varieties, the second or later seed generations should be tested before final decisions are made. Drop in performance between the first and second seed generations was more extreme with 2-clone than in multi-clone synthetics. The 2-clone group of synthetics exhibited better performance in the third and fourth seed generations than in the second; fertility relationships and the amount of selfed seed may be involved.

Testing was continued on the study of the effect of advance in seed generation of parental combinations on the syn.-1 performance of double cross synthetics. The 1948 increase study on Ranger alfalfa was concluded.

Clonal maintenance nurseries were re-established and maintained for bromegrass, orchardgrass and timothy.

Syn.-2 and syn.-3 seed was produced in row plantings of timothy, bromegrass and orchardgrass experimental synthetics. Breeder seed was obtained on larger blocks from four released or highly promising synthetics.

Evaluation and observation of DuPuits planting stocks and check lots indicated no variation in performance.

Studies comparing the first synthetic generation (composed of equal amounts of the restricted polycross seed from each of the parental clones) and the second synthetic generation (from seed plots planted with syn.-1 seed) are under way with bromegrass, orchardgrass and timothy. In general there has been very little change in the performance of these two generations and none of great practical importance. There is some indication that the results may be different with different synthetics. Too few synthetics have been studied in order to determine the effect of number of parental clones on the performance of syn.-1 and syn.-2 generations with these species.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY, WITH SPECIAL EMPHASIS ON PROBLEMS OF PRODUCTION DURING PERIODS OF MIDSUMMER DROUGHT

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, A. A. Johnson, K. F. Schertz, S. B. White and H. A. MacDonald (Agronomy) cooperating

Evaluation of varieties and mixtures has been, or is being conducted on more than 20 regional sites in New York State (1955 Annual Report, page 65). These are located throughout the agricultural areas of the state and provide an opportunity to determine performance of important varieties over a large number of environments.

Preliminary evaluation trials have been expanded to include a number of managements in order to determine performance more adequately.

Alfalfa: Because the dominant problem in marginal alfalfa areas is stand establishment, Narragansett has continued to give best performance in all areas where drainage is critical. Expected stand life in these areas seems to be too short for bacterial wilt to be more than a secondary factor.

DuPuits on good land, in short rotations, and with intensive cutting management, has outyielded other recommended varieties by a half ton of hay per season. Tests have indicated that it is not suited for marginal drainage conditions. Vernal is giving good performance. It is equal to Narragansett on good land and its persistence under wilt conditions is equal to Ranger. It does less well than Narragansett under marginal conditions. Ranger is inferior under most conditions in establishment and production to the other three varieties.

Bromegrass: Saratoga has given higher average yields than the Southern-type varieties. It is more vigorous in establishment, starts growth earlier in the spring, and produces more aftermath than standard varieties. Some tests have indicated that bromegrass suffers severe stand loss with frequent clipping. Because of competition during establishment it is inferior to timothy as a companion grass for birdsfoot trefoil. The first certified seed of Saratoga is expected to be harvested in 1958.

Red Clover: Pennscott and Dollard have usually given better performance than other standard varieties and common sorts. No significant difference in longevity has been observed.

Timothy: Later maturing varieties are believed desirable because of quality differentials at harvest time. Maturity differences greater than one week from Common result in some yield reduction in most years. Climax gives equal yields but high hay quality over a longer period than Common. Essex is two weeks later than Common and desirable for very late hay or where a minimum of competition is desired from the companion grass. The first certified seed of Essex is expected to be harvested in 1958.

Orchardgrass: Late orchardgrass varieties give less total season yield but are more easily managed than Common. Recovery and aftermath are about equal to Common. No great differences in competitive effect have been observed on companion legumes between late and early sorts.

Comparison of late orchardgrass selections vs. bromegrass has not received sufficient testing. Tests suggest that orchardgrass-alfalfa mixtures may offer maximum production with intensive management for silage and/or pasture.

Other grasses: Testing of experimental synthetics of reed canarygrass and tall oatgrass has indicated no important superiorities over currently used sorts. It is planned to discontinue testing work with these species.

Title: BIRDSFOOT TREFOIL CULTURE AND MANAGEMENT FOR HAY, PASTURE AND SILAGE

Leader: H. A. MacDonald and David Evans

Most investigations reported previously were continued during 1956. Culture and management studies of mixtures and varieties were carried out. Particular stress was devoted to the influence of plant growth habit and management practice on crop production. Seedings of birdsfoot trefoil were in all cases successful where optimum conditions for growth were provided. Mixtures with fast growing species presented a problem, however. In all cases reduced seeding rates of the companion crop and rapid growing associated species improved the resultant stand of birdsfoot trefoil. Similar benefits were obtained from the reduction of weed competition. Mixtures of birdsfoot trefoil with other grasses and legumes were most successful only where the mixture components were in ecological and physiological balance. Simple mixtures gave best results. Early and vegetatively propagated grasses were most competitive. Bromegrass made an excellent associated species early in life of the stand but on good soil became progressively dormant under management for hay. A desirable mixture continued under grazing.

Birdsfoot trefoil was found to tolerate frequent clipping to a greater degree than alfalfa but to a lesser extent than white clover. This was shown under long term grazing trials where the early varieties of birdsfoot trefoil, European and Viking, produced high yields and decreased in stand under grazing while the Empire variety maintained its stand or increased under similar treatment. This was found to be due for the most part to the ability of the latter variety to set seed under pasture conditions.

A primary cause of stand loss under use as hay, pasture or silage management was found to be the direct injurious effect of traffic on the plant. This was found to be one of the principal influences resulting in short term stands.

Title: BIRDSFOOT TREFOIL IMPROVEMENT, BREEDING AND STRAIN EVALUATION

Leaders: H. A. MacDonald, R. B. Seaney and R. Pootstchi

Many available lines, sources, and varieties of birdsfoot trefoil are under evaluation and study. Characters being investigated include seedling vigor, growth rate, yield, day length requirement, disease resistance, inheritance of growth form and habit, leafiness, HCN inheritance, bud drop, seed shattering and winter hardiness. Crosses between lines exhibiting definite differences are currently under study. Material from this project produced in 1956 will be evaluated in 1957. Particular stress is being placed upon those characters influencing forage and seed yield.

Title: BIRDSFOOT TREFOIL SEED PRODUCTION

Leaders: H. A. MacDonald, J. E. Winch and Richard Shibles

The shedding of immature flower buds from the apparently healthy plant continues to be one of the most serious problems affecting seed production. While light, length of day, temperature and moisture conditions have been found to influence bud-drop these factors do not appear to be the principal cause in most cases. The work in this area is continuing with special emphasis on insect and vegetation control.

Studies on seed development and ripening have shown rather conclusively that these processes may be divided into three periods of about ten days each following pollination. During the first period the pod structure develops to its full size with little seed development. During the second period the pod or legume is active but does not increase in size or weight, while the seed develops rapidly. The third period is principally one of maturing seed. Only during the end of this period is the seed developed to the point where it is fully viable and sufficiently dormant for harvest, processing and storage. Seed harvest at an earlier date resulted in low germination and weak seedling emergence. During the later period of seed development rapid changes were found to have taken place in seed germination and value. Immature seed was found to have little planting value while ripe seed was high in hard seed percentage. Upon scarification this seed germinated readily. However, scarification resulted in injury and a decline in total live seed.

Extensive work on rate of seeding and plant population studies showed rather conclusively that thin seedings were to be preferred for seed production. Highest seed yields resulted from stands having not more than five to eight plants to the square foot for new seedings and as low as two plants to the square foot for mature stands. Seeding rate of four pounds to the acre proved ample where good establishment was obtained. Row seedings of 36-inch width gave highest seed yield where weeds and grass were controlled. Row culture, maintenance and harvest present problems, however. Current studies indicate possible effective control by use of chemicals.

Where other factors are not limiting, plant competition seriously reduces seed yields. Overly dense stands of birdsfoot trefoil or mixtures of other plants have this effect. The competitive influence is related to both density and height of the competing plant. Many methods of reducing grass competition have been tried. In some years early clipping or grazing has delayed seed harvest and increased seed yield as much as 35 percent. In other years the seed yield has been greatly reduced by such treatment. Late clipping has almost always resulted in lower seed yields. As an alternative, considerable research has been under way on the use of chemicals for control of vegetation. While the results are as yet preliminary they look promising. The use of Dalapon at a low rate has been effective in grass control, without serious injury to the birdsfoot trefoil. At higher rates flowering and seed set have been seriously reduced. As an aid to harvest, various foliar desiccants have been effective and greatly increased the ease of direct seed harvest. Such treatment, however, also increased the rate of drying and resulted in increased seed shattering except under the most timely operation on limited acreage. Further work is in progress.

Title: FACTORS AFFECTING SEEDING ESTABLISHMENT OF FORAGE PLANTS

Leaders: H. A. MacDonald and Sheldon Whitney

In recent studies more attention has been devoted to seed characteristics and seedling requirements for germination, initial growth and development. Plant nutrition during seed development, seed maturity when harvested, seed size, processing and handling injury, and seed age were found to be important and principal causes for inferior or weak germination and initial seedling loss. In many instances normal laboratory germination was inadequate or too weak for field germination and development. These findings in no way depreciate the importance of field influences. The studies carried out have shown marked varietal differences in relation to establishment. These differences, however, have been closely related to plant vigor, rate of development, date of flowering and rate of recovery following harvest. It would appear that selection for strong initial development must be carried on in relation to these other characters. As previously reported, temperature, soil moisture, nutrition, soil composition, competition, insects and diseases, and time of seeding and development are factors of primary importance under normal field production.

Title: DISEASES OF FORAGE CROPS

Leaders: D. A. Roberts, C. S. Ramamurthi, K. D. Fezer, C. H. Ward, J. M. Kainski and R. E. Ford

Crop losses in 1956 due to black stem of alfalfa, northern anthracnose of red clover, and brown spot of bromegrass were relatively high, but only negligible losses were caused by other diseases of above-ground parts of forage crops in New York. Hay losses were lower in 1956 than in any of the pre-

ceding 4 years, probably as a consequence of the unusually cold weather during the spring (1955 Annual Report, page 70).

Fusarium solani and F. oxysporum were the fungi isolated most frequently from diseased red clover roots. Both fungi were pathogenic to roots of red clover plants of all ages, and are at least partly responsible for failure of red clover plants to survive more than 2 years under field conditions. Control of the clover root borer in experimental plots resulted in less severe root rot, but resulted in only slightly increased plant persistence into the third year, and this occurred in only a few instances.

Species of Fusarium and of other fungi were found associated with diseased roots of birdsfoot trefoil in all sections of New York. Investigations on the importance of root rots in the production of birdsfoot trefoil are being continued.

The detached-leaflet technique is proving to be useful in testing alfalfa plants for resistance to black stem. Gomphrena globosa L. is a local-lesion host for the red clover vein mosaic virus, and probably will be a useful plant for biological assay of that virus.

A study of incubation and infection phenomena concerning Stemphylium loti is under way, and Lotus spp. are being tested for resistance to the copper-spot disease caused by S. loti.

Title: A COMPARISON OF DIFFERENT INTENSITIES OF GRAZING WITH GREEN CROP FEEDING OF AN IMPROVED PASTURE MIXTURE

Leaders: J. T. Reid, W. K. Kennedy, K. L. Turk, H. A. MacDonald and N. C. Brady

An alfalfa-Ladino clover-bromegrass pasture is being utilized in a comparison of the following management methods: semi-continuous, rotational, strip and zero grazing. The criteria being employed are: Milk production, seasonal carrying capacity, herbage consumption rate, cost of production and the botanical and chemical composition of the sward. This project is intended to be of 5 years' duration, of which the 1956 season was the first.

Title: THE RELATIONSHIP OF TIME OF CUTTING TO THE DIGESTIBILITY OF DIFFERENT FORAGES

Leaders: J. T. Reid and W. K. Kennedy

During 1956, the digestibility of six additional samples of forage was studied. These tests were of particular interest because of the peculiarities of the 1956 growing season. However, despite the nature of the season, the digestibility of the 1956 crops was found to conform to the relationship between the time of cutting and digestibility derived from studies of

forages during the seven previous years. To date over 80 first-cut forages have been examined. The equation expressing this relationship is Y = 85.1 - 0.47X, where Y = digestibility of the dry matter and X = harvesting time in days after April 30. The standard deviation from regression is 1.64%. The digestibility of aftermath forages has ranged from 58 to 63%. These relationships have their greatest significance in giving the farmer a tool by use of which he can determine how much of concentrates to feed livestock.

Title: THE DEVELOPMENT AND USE OF INDIRECT METHODS FOR THE MEASUREMENT OF DIGESTIBILITY AND RATE OF CONSUMPTION OF FEEDSTUFFS, PARTICULARLY FORAGES, BY RUMINANTS

Leaders: J. T. Reid, K. L. Turk, A. M. Smith, J. W. Stroud and J. A. Holter

The studies made during the last seven years culminated in devising methods for measuring the chemical composition, digestibility and intake of forage as selected by grazing animals. These methods have been employed to evaluate several pastures and to determine the efficiency of grazing methods. As the result of employing these methods it was found that grazing cows require 10 to 12 pounds more of TDN per day to support maintenance than do stall-confined cows. This appears to be the result of an additional need for locomotion, and might be influenced by length of light day and temperature.

Further studies dealing with the refinement of digestibility indicator methods have been made. Experiments in which (1) approximately thirty hays ranging in total protein content from 6 to 34% were fed to sheep and (2) about thirty green forages ranging from 5 to 33% total protein were fed to cattle, show that "indigestible" protein can be employed as an accurate indicator of digestibility. The data obtained with approximately 50 hays and silages harvested at various times and fed to cattle are being processed. The results to date have been encouraging and this scheme appears to be applicable to group-feeding.

A new approach to the measurement of net energy values of forages is being examined. Experiments conducted to date have revealed that: (1) The chemical composition and calorific value of the bodies of cattle can be predicted from the body water content, (2) Several substances (tritium, antipyrine and N-acetyl-4-aminoantipyrine) may be employed as reference materials for the measurement of body water in the living animal, (3) Peculiarities in the distribution of the reference substances in the water of the gastrointestinal tract require further study in order to adapt these methods to routine use in feeding trial experiments, and (4) The adaptation of these methods to measuring net energy values in feeding experiments is not insurmountable and would allow this evaluation to be made under usual, natural conditions of feeding and grazing.

Title: EUROPEAN CHAFER INVESTIGATIONS

Leaders: H. H. Shorey and G. G. Gyrisco

Heptachlor at 0.5 pound per acre of actual toxicant applied as a dust, granulated dust or a wettable powder spray and at 1.0 pound per acre of actual toxicant applied as an emulsion spray gave almost complete control of European chafer larvae in meadow and pasture sod. Low dosages of dieldrin (0.12 to 0.5 pounds per acre) were more effective than similar dosages of heptachlor in reducing populations of grubs. No differences were found in control of grubs from the use of attaclay, vermiculite and tobacco stems as a granulated carrier for aldrin and dieldrin.

The plots of two previous experiments were resampled to determine the residual effectiveness of several insecticides over a 4-year period (1955 Annual Report, page 71). The treatments and rates of application in pounds per acre, arranged in the order of decreasing effectiveness were: dieldrin (2 lbs.), dieldrin (1 lb.), aldrin (2 lbs.), heptachlor (2 lbs.), chlordane (10 lbs.), aldrin (1 lb.), heptachlor (1 lb.), toxaphene (20 lbs.), and toxaphene (10 lbs.). Dieldrin at both 1 and 2 pounds gave significantly better control than did heptachlor at 1 pound and toxaphene at 10 and 20 pounds but were no better than the other treatments. In another experiment conducted over a 7-year period, it was found that chlordane at 8 pounds per acre gave nearly perfect control, BHC was intermediate and parathion poor at the same dosage. Three years after application parathion had lost all of its effectiveness, BHC persisted for 6 years but at a lower rate of efficiency and chlordane still gave excellent control over the entire period.

On winter wheat it was found that neither dieldrin at 4 pounds nor chlordane at 20 pounds per acre applied either in November or April reduced grub populations, increased yields or stand.

A study was made to determine the effectiveness of treating the soil to reduce beetle (adult) populations. It was found that two pounds of dieldrin applied 10 weeks before flight time was most effective in reducing beetle emergence. Applications of insecticides 1 year or 5 days before flight were less effective. Males were found to be more susceptible than females to such treatments but treatments reduced egg laying of the females by more than 50 percent.

Title: INVESTIGATIONS OF INSECTS INJURIOUS TO BIRDSFOOT TREFOIL

Leaders: H. H. Neunzig and G. G. Gyrisco

During 1956, investigations were concerned with the biology, ecology and control of the seed chalcid, Bruchophagus gibbus (Boh.), (1955 Annual Report, page 72). It was determined that the insect passes through 5 instars as a larva within the seed of birdsfoot trefoil. About one-half of the seed is eaten by the last instar. Seed chalcids were found to be able to transform to adults over a wide range of humidity. Normal sized adults developed from last instar larvae maintained under relative humidities of 10-100 percent. The rate of development of the pupa increased with increasing humidities, with an optimum rate of development at approximately 90 percent relative humidity. Each female lays an average of 52.6 eggs over a several week egg-laying period. Females were found to live an average of 17 days while males only lived an average of 6 days. It was found that female chalcids collected from birdsfoot trefoil restricted their egg laying to birdsfoot trefoil or other species of Lotus and did not oviposit on red clover or alfalfa. Forty percent of the chalcids in some stands of trefoil were destroyed by the parasite, Tetrastichus bruchophagi (Gahan). Other parasites which reduce chalcid infestation are Habrocytus medicaginis (Gahan), Amblymerus bruchophagi (Gahan), Eupelmella vesicularis (Retzius) and Eupelma allyni (French). Dieldrin at 2 pounds per acre of actual toxicant applied 2 weeks after blossoming reduced chalcid populations 92 percent. Lindane at 1 pound per acre was also quite satisfactory.

Title: ALFALFA SNOUT BEETLE INVESTIGATIONS

Leaders: C. S. Koehler and G. G. Gyrisco

It was found that alfalfa snout beetle baits containing either one-half of the recommended quantity of soybean flour or sugar, or both, gave excellent control (97 percent or better) of the adults throughout the test period (1955 Annual Report, page 73). It would appear, therefore, that either or both of these ingredients can be reduced by one-half in the standard snout beetle formula.

Dieldrin applied at the rate of 5 pounds per acre showed promise for the control of the larva of the alfalfa snout beetle. A large field experiment covering 30 acres and composed of 10 replications was set up to determine the practicability of such a control measure.

Title: CLOVER ROOT BORER STUDIES

Leaders: C. S. Koehler and G. G. Gyrisco

Clover root borer studies in 1956 consisted of work on the biology, ecology and economic importance of the insect (1955 Annual Report, page 73).

Approximately 40 percent of the first crop year plants were infested by June 15 and over 95 percent by August with an average of 9.9 borers per plant. Numbers of borers were dependent upon either available soil moisture, root size or both. The sex ratio was found to vary between ages with females outnumbering the males 10:1 in the old beetles although the ratio was nearly 1:1 for young borers. Larvae were found to be able to pass through a variable number of instars from 4 to 6 with 4 being the most common number. Eggs are very susceptible to relative humidities of less than 95 percent and frequently fail to hatch at lower humidities. Larvae are able to withstand variable humidities as low as 25 percent. For survival pupae were found to require relative humidities of 50 percent or greater. Larvae when introduced into dead clover roots which had died recently were found to be able to develop successfully into adults in such plants.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (*MEDICAGO SATIVA* L.)

Leaders: H. R. Fortmann and R. W. Cleveland

Variety trial plantings established at seven locations in Pennsylvania in 1955 were harvested for yield in 1956. The yields obtained were as follows:

Total season yields of alfalfa varieties. Averages for seven locations in Pennsylvania in 1956. Yields expressed in tons of dry matter per acre of the alfalfa fraction.

Variety	Average for all Locations
DuPuits	3.28
Vernal	3.06
Atlantic	2.87
Narragansett	2.85
Grimm	2.55
A-224	2.52
Ranger	2.34
Buffalo	2.18
Nomad	1.98
Average	2.62
L.S.D.(.05)	0.21

Evaluation of materials in uniform nurseries was continued in 1956. Spaced plantings of rhizomatous clones have been maintained, but no observations were made in the last year.

Spaced plantings of alfalfa clones collected in domestic explorations were established. In the main, the clones involved were selected from old stands of alfalfa in various localities in Pennsylvania. Survival in stands heavily infested with bacterial wilt and/or crown rot was the principal basis for selection. Further evaluation of this material will be made in 1957.

Results of a seed usage survey for Pennsylvania show that alfalfa has become the leading forage legume in this state. Seed usage of alfalfa totaled 3,653,000 pounds in 1955-56, indicating that about 300,000 acres were established in this year. The details of the seed usage survey reported on a variety basis for all important forage species were published in Pennsylvania State University Progress Report 152 (Fortmann and Johnston, 1956).

Cooperative Regional evaluation of clones and progenies under NE-28 has continued

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: H. R. Fortmann and R. W. Cleveland

Variety yield trials established in 1955 were harvested at seven locations in Pennsylvania. The yields obtained were as follows:

Total season yields of red clover varieties. Averages for seven locations in Pennsylvania in 1956. Yields expressed in tons of dry matter per acre of the red clover fraction.

Variety	Average for all Locations
Pennscott	2.55
Kenland	2.11
Dollard	1.86
Common	1.77
Average	2.07
L.S.D. (.05)	0.21

An experimental planting for the evaluation of red clover lines selected as apparently persistent in a previous disease nursery (1954 Annual Report, page 73) was harvested for yield in 1956. No selections were superior in yield to Pennscott. Observations of third year stand will be made in 1957.

A disease nursery including a large number of varieties and strains of red clover was established in 1956. Inoculation of this planting with northern anthracnose is planned for 1957 in cooperation with Dr. Houston Couch. An

attempt will be made to evaluate red clover varieties and strains for resistance to northern anthracnose and to select individuals which are resistant to this disease.

Local strains of red clover collected in previous domestic explorations in Pennsylvania were established in a yield trial in 1956.

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL

Leaders: H. R. Fortmann and R. W. Cleveland

Data were obtained on variety yield trials established at five locations in Pennsylvania in 1955. Results are reported as follows:

Total season yields of birdsfoot trefoil varieties. Averages for five locations in Pennsylvania in 1956. Yields expressed in tons of dry matter per acre of the birdsfoot trefoil fraction.

Variety	Average for all Locations
Viking	1.34
Mansfield	1.25
Cascade	1.27
Granger	1.39
Empire	1.05
Imported	1.01
Average	1.22
L.S.D. (.05)	0.13

Four experimental synthetics were formulated, with constitutions as follows:

Synthetics			
55-1	55-2	55-3	55-4
C-1	C-1	C-37	C-38
C-2	C-2	C-40	C-39
C-7	C-6	C-50	C-50
C-10	C-10	C-78	C-51
C-25	C-25	C-96	C-69
C-30	C-31	C-112	C-95

The first two synthetics are composed of Empire-type clones, and are thus later maturing, presumably pasture-type trefoil varieties. Synthetics three and four are composed of early maturing clones selected from European source materials. Seed increase plots were established in isolation in 1956, and presumably seed will be available in 1957 for testing.

Cooperative regional evaluation of clones and progenies was continued in 1956 under the NE-28 project.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: H. R. Fortmann and R. W. Cleveland

The outstate variety trials planted in 1955 were successful at seven of the eight locations. The yields obtained are as follows:

Total season yields of grass varieties. Averages for seven locations in Pennsylvania in 1956. Yields expressed in tons of dry matter per acre of the grass fraction.

Orchardgrass

Variety	Average for all Locations
Common	3.69
Penna. Early Syn. I	3.77
Potomac	3.65
P. L. Syn. I	3.68
Penna. Medium Syn. II	3.86
Penna. Late Syn. III	3.79
S-37	2.68
P. L. Syn. V	3.46
Average	3.57
L.S.D. (.05)	0.18

Bromegrass

Variety	Average for all Locations
Manchar	3.24
Lincoln	3.34
Average	3.29
L.S.D. (.05)	N.S.

Timothy

Variety	Average for all Locations
Climax	3.03
Common	3.27
Average	3.15
L.S.D. (.05)	0.17

Orchardgrass Synthetics: Because of a partial export embargo on S-37 seed from the United Kingdom, and because of problems of establishing and maintaining stands of S-37, Pennsylvania late Synthetic #3 is to be considered for official experiment station release at the end of the 1957 growing season. This synthetic has appeared very promising in research trials (see yield data listed above.) A contract has been made for the production of foundation seed in California. It is possible, but not assured, that foundation seed will be obtained this summer. The clonal formulation of Pennsylvania Late Synthetic #3 is as follows: MIV - 5, MIV - 17, XLI - 8, and XLI - 17. A new nursery for the production of breeder seed will be established in the coming year.

The five orchardgrass experimental synthetics listed in 1955 Annual Report, page 77, produced adequate seed for testing and will be evaluated in the coming year.

Three new orchardgrass synthetics were formulated with regional cooperation under NE-28.

Other Investigations: Intensive studies on orchardgrass and bromegrass breeding materials were made in masters theses' investigations by Mr. George Gorsline and Mr. Richard Cole. The subject matter content is indicated by the theses titles listed in the citations.

A cytogenetic study of hybrids between Phalaris arundinacea and Phalaris tuberosa has been continued in 1956 by Mr. J. L. Starling. A number of hybrids from this cross have been obtained and are being studied cytologically.

Evaluation of F_2 material from a similar cross between these two species of Phalaris has been carried on in 1956 (Material obtained from Dr. R. M. Love, University of California). Superior F_2 plants and F_3 progenies will be studied in 1957.

Cooperative investigations of clones, progenies, and experimental synthetics were continued under the NE-28 project in 1956. Bromegrass and orchardgrass breeding materials are currently under regional evaluation.

Title: THE INTRODUCTION AND EVALUATION OF FORAGE CROPS BREEDING STOCKS

Leaders: H. R. Fortmann, H. B. Sprague and R. W. Cleveland

This project was activated in the autumn of 1956, and the effort to this time has been directed to the accumulation of introduced seed stocks of many forage species which will be planted in observation nurseries in 1957.

Title: GRAZING NEW STRAINS OF LEGUMES AND GRASSES IN MIXTURES

Leaders: J. B. Washko and P. S. Williams

The following mixtures were grazed for the fourth year with Holstein dairy cattle on 1/2-acre paddocks, replicated 3 times; S-37 orchardgrass-Buffalo alfalfa, Kentucky bluegrass-Empire birdsfoot trefoil, Tualatin tall oatgrass-Empire Birdsfoot trefoil, reed canarygrass-Empire birdsfoot trefoil, and S-37 orchardgrass-Empire birdsfoot trefoil.

The S-37 orchardgrass-Buffalo alfalfa mixture continued to be the most productive pasture mixture when evaluated under rotational grazing in terms of dry matter production and grazing days per acre. The Kentucky bluegrass-birdsfoot trefoil combination was next best and the other three mixtures were approximately equal in value. Of the various grass species, tall oatgrass was least persistent, whereas the S-37 orchardgrass and Kentucky bluegrass was most persistent.

Title: FORAGE PRODUCTION OF RYE AND ANNUAL WINTER GRASSES

Leader: J. B. Washko

Tetra Petkus, Balbo rye, field bromegrass, and domestic ryegrass were compared at two seeding rates under two methods of fertilization, and split vs. single spring nitrogen top-dressings for forage production. The fertilization practices consisted of applying 365 lbs. per acre of a 10-10-10 fertilizer with the seed and prior to seeding. A single 60-pound spring nitrogen top-dressing application was compared with a split application of 30 pounds each.

The main results obtained from this experiment were as follows: (1) The highest total forage yield for both the fall and spring periods was produced by Balbo rye, followed in descending order by field brome, Tetra Petkus rye and domestic ryegrass. Tetra Petkus rye out-yielded Balbo rye in the fall, whereas in the spring the reverse was true with respect to forage production. Domestic ryegrass and field brome were approximately two weeks later in reaching the pasture stage in the spring than the ryes. The placement of 365 lbs. per acre of a 10-10-10 fertilizer with the seed of both rye varieties injured germination and caused a marked reduction in fall forage production. By spring, the rye had outgrown this injury so forage production was no longer affected.

Raising the seeding rate of the ryes from 2 to 3 bushels per acre greatly increased fall forage yields but had no influence on those harvested in the spring. Similarly, when the seeding rate of domestic ryegrass and field brome were raised from 20 to 30 pounds per acre, better ground cover was obtained in the early spring, but forage production was unaffected. The single 60-pound nitrogen top-dressing was just as effective in increasing

forage production as splitting the application, applying one half in March and the other half after the first grazing in May.

Title: RENOVATION OF UNPRODUCTIVE PASTURES

Leader: J. B. Washko

Experiments are being conducted to evaluate the relative merits of various sod treatments, fertilizers, and forage mixtures for pasture renovation. Forage production was measured on 5 experiments subjected to grazing at University Park and other locations in the state during 1956. Two experiments, one at University Park, and one at Wellsboro were in their fourth productive year, another at U.P. was in its third year and the remaining two were in their second year at U.P. and Dushore, respectively.

The residual value of renovation was still very evident in the fourth productive year following renovation. At University Park, Empire birdsfoot trefoil and timothy produced 3.73 tons of dry matter per acre, Viking birdsfoot trefoil and timothy 3.25 as compared with 2.15 tons for Ladino clover-orchardgrass and 1.44 tons for Kentucky bluegrass pastures. Similarly at Wellsboro in the fourth year following renovation, a mixture of Viking trefoil with bromegrass and timothy yielded 2.89 tons of dry matter per acre, Empire with the same grasses 2.61, orchardgrass-Ladino clover 1.12 tons and Kentucky bluegrass pasture .29 tons per acre respectively.

Title: SEEDING AND ESTABLISHMENT OF GRASSLANDS

Leader: J. B. Washko

Spring seedings of alfalfa-bromegrass, Ladino-clover-orchardgrass, and birdsfoot trefoil-timothy were made in winter barley, winter wheat, spring oats, and in a prepared seedbed without a nurse crop with implements incorporating the following methods in 1955: (1) Band-seeding in 8-inch rows with press wheels, (2) Band-seeding in 10-inch rows, (3) Band-seeding in 20-inch rows, (4) Band-seeding in 7-inch rows, (5) Broadcast seeding with cultipacking, (6) Broadcast seeding from power take-off of tractor, and (7) Broadcast seeding on frozen ground. Stand counts as well as root and plant development measurements were made in 1955 and dry matter yields were taken during 1956 on these plots.

Forage yields were somewhat higher for all mixtures established without a companion crop and with spring oats as a companion crop. Since the month of May was one of the driest on record at University Park, the oat crop was almost a failure, hence offered but little competition to the new seedings. Forage yields established with the winter small grains averaged from .2 to .3 tons per acre less than where no small grain was used.

Better establishment of the alfalfa-brome mixture was obtained with implements embodying the band seeding principle than the broadcast principle. This was reflected in higher forage production the year following establishment. Ladino clover-orchardgrass and birdsfoot trefoil-timothy mixtures were established equally well by all implements irrespective of whether the band or broadcast seeding principle was used. These two mixtures, therefore, appear less sensitive to seeding methods than the alfalfa-bromegrass mixture.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: E. F. Sullivan and J. B. Washko, G. R. Kean, R. C. Miller, J. K. Pasto, and A. L. Haskins (with cooperation of Rockview Branch of Pennsylvania Department of Penal Institutions)

Steer responses to 4 systems of management were recorded in 1956. Pasture swards utilized were commercial orchardgrass, S-37 orchardgrass or commercial bluegrass alone, whereas, the mixed swards contained one of the above grasses plus Ladino clover, Buffalo alfalfa, or Empire birdsfoot trefoil. Thirty steers were used per system. System I (legume-grass sward only), system II (grass sward only plus 80 pounds of nitrogen per acre), and system III (legume grass sward + 5 pounds of grain per steer per day) utilized 102, 94, and 94 acres which produced 99.2, 97.6, and 108.4 tons of grazable dry matter respectively during the 120-day test. About 240 green weight tons of excess forage were ensiled but not fed to steers on test. System IV (dry lot feeding only) was considered standard. The following gains per steer per day were obtained during 120 days: System I, 1.66 pounds, system II, 1.42 pounds, system III, 1.94 pounds, and system IV, 2.81 pounds. Buyer assay at the end of the test period gave moderate gains in animal grade to systems III and IV. Systems I and II remained unchanged. After the initial 120 days, a subsample of 10 steers from each system was carried on dry lot feed for 60 days. The average steer gain per day and gain in grade for each system follows: System I, 2.17 pounds, L. G. to A. G., II, 2.32 pounds, A. S. to L. G., III, 2.57 pounds, H. S. to L. G., and IV, 1.64 pounds, H. G. (no change). It is believed that grass pasture production (system III), therefore crude protein, was limited by nitrogen deficiencies during the test.

Title: IMPORTANCE OF ROUGHAGE QUALITY IN THE DIET OF YOUNG DAIRY CALVES

Leader: E. M. Kesler and N. H. Gotwalt

Hays and silages of varying quality are under investigation with respect to their relative importance in the diet of calves under four months of age. In the first trial 48 male Holstein calves were divided into 4 groups at 6 days of age and fed the following roughages ad lib.: a fair quality mixed hay, good quality alfalfa silage, mixed hay and alfalfa silage, and mixed hay and corn silage. All calves were fed milk replacement to 6 weeks of age, and a commercial calf starter was provided free choice up to a maximum

of 4 lbs. daily. Duration of the trial was 16 weeks. Growth response was greatest in calves fed alfalfa silage, followed in order by those fed mixed hay and alfalfa silage, those fed mixed hay alone, with the corn silage-fed calves showing the poorest growth response. Nutrient intake paralleled growth. An additional trial is underway wherein only hays of varying quality and composition are being fed.

Title: METHODS OF PRESERVATION AND THE MEASUREMENT OF THE NUTRITIVE VALUE OF FORAGE CROPS

Leaders: J. W. Bratzler, E. Keck, Jr., R. W. Swift and J. B. Washko

The trench silo filled during the 1955 season (1955 Annual Report, page 81) upon which dry matter losses were determined for four separate zones of the trench gave the following results:

Zone	Treatment	Loss of Dry Matter
		(%)
Covered Trench	Bisulfite Treated	12.0
Covered Trench	Untreated	23.7
Uncovered Trench	Bisulfite Treated	31.4
Uncovered Trench	Untreated	29.7

All trench silages except that from the bisulfite-treated covered zone were of very poor quality, as indicated by strong odors and high pH values. The silage from the treated covered zone was comparable in quality and retention of nutrients to that made in upright silos.

Results regarding the palatability of silages made from first cutting alfalfa with varying rates of application of bisulfite (1954 Annual Report, page 78) were as follows:

Bisulfite Treatment	No. heifers (Ave. wt. 668 lb.)	Average daily consumption for group	Number days fed
		lb.	
5 lb. per ton	22	1112	7
8 lb. per ton	22	1022	4
12 lb. per ton	22	951	6
18 lb. per ton	22	835	9

The above results were somewhat affected by intermittent periods of below-zero weather during which silage consumption was sharply reduced due to freezing of the silage before it could be eaten. In view of this observation and after a careful examination of the daily consumption data in conjunction with weather records, it appears that a significant reduction of intake of silage occurred only at the highest rate of application of bisulfite.

During the 1956 season oats, grown as a companion crop with a new pasture seeding, was harvested with the direct-cut forage harvester at the following stages of maturity: (1) in flower, (2) in milk, and (3) early dough. One load harvested at each of these stages of maturity provided a sufficient quantity of the fresh forage to fill two 4' x 8' steel silos. No preservative was added to one silo while the forage in the second silo was treated with bisulfite at 12 pounds per ton of forage. Both the bag and in-and-out techniques were employed to measure losses of nutrients that occurred during the ensiling process. The six silages have been fed to sheep in order to determine the nutritive value of each. Digestible dry matter values for the three silages which had received no preservative were (1) in flower, 67.1%; (2) in milk, 60.0%; and (3) early dough, 57.9%. Significant differences were also noted in the crude protein contents, dry matter basis, of the fresh oats forage with the earliest cut forage having a crude protein content of nearly 13 percent while the latest cut forage contained less than 9 percent.

First-cutting alfalfa, harvested at the bud stage with the direct-cut forage harvester, was ensiled in 4' x 8' steel silos in two replicates of three silos each. The treatments were: (1) no preservative, (2) 14 lb. bisulfite/ton, and (3) 6 lb. Kylage/ton. One load of the freshly chopped forage was used to fill each replicate of three silos on successive days. Each silo was filled with a weighed quantity of the fresh forage to within two feet of the top of the silo at which point a sheet of sisal-kraft paper was inserted and the filling of the silo was then completed with more of the fresh forage. The forage in each silo was immediately weighted with 1000 pounds of concrete. Total seepage was collected from each silo. The bag technique for determination of nutrient losses of ensiled forages was used in addition to the in-and-out measurements made on the quantity of forage ensiled and quantity of silage removed. The silages from the above six silos are now in the process of being evaluated nutritionally with sheep. In none of the silos when opened was there any spoilage underneath the layer of paper so that this form of loss during the ensiling process will not enter into consideration of the nutrient losses which occurred during the ensiling process. Two additional 4' x 8' steel silos were filled with corn silage with no preservative added to one silo and bisulfite at the rate of 11 pounds per ton to the other.

Title: SUPPLEMENTAL IRRIGATION FOR MAXIMUM PRODUCTION OF AGRONOMIC CROPS

Leaders: L. T. Kardos and J. B. Washko (with the cooperation of Department of Agricultural Engineering and U. S. Regional Pasture Research Laboratory)

Seedings of alfalfa, alfalfa-orchardgrass (S-37), Ladino clover, Ladino-orchardgrass, birdsfoot trefoil, birdsfoot trefoil-orchardgrass, and orchardgrass were successfully established on two areas, one of which received deep placement of fertilizer. The latter consisted of placement of 5-10-10 fertilizer at a depth of 14 inches and with a horizontal spacing of 18 inches. The fertilizer applied was equivalent to a rate of 670 lbs. per acre. The machinery used for the deep placement consisted of a Pittsburgh Forging Co. Deep Feeder mounted on a heavy duty Ford tractor (Model 960).

Moisture sensing resistance units were placed in one complete set of the irrigated and the non-irrigated plots in order to evaluate the moisture depletion in the root zone to a depth of 28 inches. Irrigation was to be made when 30 percent depletion of the available soil water at the 4-inch depth was attained on one set of plots and when 85 percent depletion of the soil water at the 4-inch depth or 30 percent depletion at the 12-inch depth was attained on a second set of plots.

During the growing season the climatological conditions were such that at no time was the soil moisture depleted to the index values for irrigation. The total precipitation from planting time, May 1, to October 31, 1956, was 29.38 inches with a distribution such that no ten day interval beginning May 1 and continuing through September 17 had less than 1.0 inch of precipitation. The normal precipitation for this period is 23.2 inches. July and September were below normal in temperature. June was slightly above normal and August was normal. The mean for the 5-month period was 1.2 degrees below normal.

A program has also been initiated for characterizing the moisture release properties of natural core samples which are being secured in soil profile sampling for the accelerated soil survey program in Pennsylvania. During 1956, 70 core samples were secured from 8 soil profiles in Erie and Chester counties. Colman fiberglass resistance units were inserted in the 3" x 3" cores and they are now passing through the first drying cycle.

During the coming year, moisture depletion will be studied with all crops involved in the project. Root distribution studies will be made, using a core sampling procedure. As soil profiles are sampled during 1957, additional core samples will be obtained to characterize the moisture supplying power of the various horizons.

Title: FORAGE INSECTS

Leader: Norris D. Blackburn

Major research efforts were concentrated on the alfalfa weevil during the past season. At the present time, this insect is the most important pest in southeastern Pennsylvania and may eventually prove to be the limiting factor in the production of alfalfa throughout the State. The rate of the northward and westward spread of the weevil in Pennsylvania appears to have slowed somewhat during the 1956 season. It was found last year in one new county near the Maryland border, and is now known to occur in 25 counties south of a diagonal drawn roughly across the State from the New York line on the Delaware River southwest to Fulton County.

Experiments conducted in Adams and York counties were designed to provide information on the relative effectiveness of single applications of various materials in suppressing larval populations of the alfalfa weevil. Insecticides included endrin, dieldrin, heptachlor, lindane, and a 1:1 heptachlor-benzene hexachloride combination as emulsifiable concentrates and a granulated formulation of heptachlor.

Single applications of emulsifiable concentrates during the early growth stages of the alfalfa, as well as later at the time of incipient larval activity, produced significant initial reductions in larval population levels, but their subsequent effectiveness was not sufficient to prevent extensive foliage damage before harvest of the first crop. When applications of heptachlor at the rate of 6 ounces (active) per acre were delayed until moderate to severe foliage injury had occurred, only the one made when the plants were about 20 inches high suppressed the larval populations until harvest. This was too late to have practical significance because extensive foliage injury had already occurred. In addition, the damage caused by spray equipment when used on plants of this height is of considerable importance. These experiments with emulsifiable concentrates indicated that single applications, even when delayed until larval feeding became noticeable, were not adequate, under the conditions prevailing during the 1956 season in southern Pennsylvania, to protect the foliage of the first crop of alfalfa until harvest.

Applications of granulated heptachlor (2-1/2%) at the rate of 44 ounces (active) per acre on April 27 before incipient larval activity maintained a control level of approximately 99% until harvest 53 days later. Although the application rate employed in these experiments was probably much higher than that required for practical control, the results demonstrated that this insect may be effectively controlled by early-season applications of insecticides when suitable materials are used. In fields where the alfalfa weevil has not been controlled on the first crop, the larvae and possibly newly emerged adults seriously retard the growth of the second and, when unusually abundant, may kill the plants entirely. Preliminary experiments conducted

under such conditions indicated that granulated heptachlor, applied in replicated blocks to the stubble at the rate of 24 ounces (active) per acre, reduced the larval population levels approximately 99% when compared with untreated plots.

Preliminary data on other forage pests indicate that granulated formulations of insecticides may prove to be superior to emulsifiable concentrates in the control of certain species, especially those which spend considerable time on the floor of the forage environment.

RHODE ISLAND

Title: MYCOTIC FOLIAR DISEASES OF ALFALFA IN RHODE ISLAND AND THEIR CONTROL WITH FUNGICIDES

Leaders: J. Troll and F. L. Howard

Observations on the succession of disease developing on the three seasonal cuttings or crops were continued in 1956 (1955 Annual Report, page 85). Whereas in 1955 the incidence of Stemphylium botryosum, Pseudopeziza medicaginis and Ascochyta imperfecta remained low (10%) until the last-named fungus became severe (60%) on the third crop, in 1956 both S. botryosum and P. medicaginis caused spotting up to 54 percent of leaf area in the second and third crops. Of six varieties compared in replicated adjacent plots, Narragansett foliage suffered the least injury from fungi in 1955 and Buffalo in 1956.

Laboratory evaluation of the toxicity of many fungicides to A. imperfecta and S. botryosum placed a phenyl mercurial ("Liquiphene") and a basic dye "malachite green" at the top. Field applications just prior to spring growth, and immediately after each cutting appeared to reduce the degree of disease. At present, the use of a "broad spectrum" fungicide to reduce the inoculum potential of all the above-named pathogens appears most promising.

Title: SOIL FERTILITY AND SOIL MOISTURE RELATIONS IN GRASSLANDS IN THE NORTHEAST

Leaders: R. C. Wakefield, M. Salomon and C. E. Olney

Response of Ladino clover to increments of phosphate and potash up to 240 pounds per acre was determined on a soil of initially low pH and fertility (1955 Annual Report, page 84). Dry matter yields of Ladino clover decreased steadily over the four year harvest period but satisfactory stands were maintained with 60 pounds P_2O_5 and 120 pounds K_2O per acre per year. Large initial applications of phosphate were not so effective as similar amounts divided over a period of two or four years. Banding of superphosphate was

more effective than broadcasting on the surface and/or disking in.

Potassium content of plant tissue increased significantly as increments of potash were applied. Removal of potassium by the crop exceeded applications at low levels, approximately equalled the 120-pound per acre application and resulted in excessive uptake at 240 pounds per acre. The magnesium and sodium content of the crop were significantly depressed at 240 pounds K_2O per acre. Accumulation of exchangeable and nonexchangeable potassium in the soil was found only at the 240-pound rate. A decrease in nonexchangeable potassium occurred at the 0-, 30-, and 60-pound rates.

No accumulation of extractable phosphorus was found at any level of phosphate application. Magnesium increased considerably and calcium did not change during the experimental period.

Title: POTASH SOURCES AND RATIOS

Leaders: T. E. Odland, R. C. Wakefield and M. Salomon

Yields and botanical composition of a Ladino clover-bromegrass mixture were determined during a fifth harvest year (1955 Annual Report, page 85). Heavy winter killing of Ladino clover during the winter of 1955-56 reduced stands so that only small harvests were obtained. The yields of dry matter varied from 0.98 to 1.78 tons per acre.

This experiment was discontinued at the end of the 1956 season and the 5-years' results summarized. The 5-year average yields in forage with 12 percent moisture ranged from 2.86 tons per acre with no potash supplied in the fertilizer to 3.74 tons with 320 pounds of K_2O per acre applied. The average yield with 160 pounds K_2O was 3.63 tons. There was no significant increase in average yields when more than 160 pounds of K_2O was applied.

Title: INSECT AND OTHER ALLIED PESTS OF FORAGE CROPS AND THEIR CONTROL UNDER RHODE ISLAND CONDITIONS

Leaders: T. W. Kerr and C. E. Olney

Annual surveys of leafhoppers associated with alfalfa, red clover and several legume-grass associations in Rhode Island during the period of 1948 to 1956, exclusive of 1950, yielded information on: (1) the relative abundance of the 14 species found, (2) their distribution throughout the season, and (3) the preferred host plants of the most numerous species. The most abundant species in the order given were Macrosteles fascifrons (Stal), Endria inimica (Say), Graminella nigrifrons (Forbes), Agallia constricta Van D., Empoasca fabae (Harr.) and Aceratagallia sanguinolenta (Prov.). Populations of M. fascifrons which were greatest in mid-June, late July and early September, were more prevalent on red clover and bromegrass-Ladino clover

pastures than on alfalfa. Peak populations of E. inimica occurred in early July and early September. It preferred various legume-grass associations to alfalfa and red clover. Peak populations of G. nigrifrons occurred in late June, mid-August and late September and it was more prevalent on red clover and various legume-grass associations than on alfalfa. E. fabae, which had no distinct peaks of population showed a preference for alfalfa. A. sanguinolenta preferred red clover and Ladino clover to alfalfa. It had peak populations in mid-July and late August.

Title: THE VALUE OF GRASS-LEGUME SILAGE AS SOLE ROUGHAGE FOR DAIRY CATTLE

Leaders: J. W. Cobble, B. W. Henderson, Jr., and G. Wildes, with the cooperation of the Agricultural Chemistry Department

This study was initiated in 1954 (1955 Annual Report, page 87). Results for a three year double reversal feeding procedure as follows:

Feed	No. Animals	Average Dry Matter Intake	Average T.D.N. Calculated	Average F.C.M. Production	FCM/lb. T.D.N.	Body Weight Changes
		lbs.	lbs.	lbs.	lbs.	lbs.
Silage	18	26.2	17.2	33.3	1.93	-11
Hay and Silage	18	29.3	18.9	31.9	1.69	+ 5

Title: SOILAGE FEEDING OF DAIRY CATTLE

Leaders: J. W. Cobble, B. W. Henderson, Jr., and H. Cook, with the Departments of Agricultural Economics and Agronomy

The objectives of this study are to determine the effect on milk production and body weight of dairy cattle and growth of heifers when fed green chopped forage in dry lot as compared to conventional pasturing practices (1955 Annual report, page 86). The following conclusions are made from a three year study: (1) Less acreage per cow is required for the cropping period, (2) Greater production of fat-corrected milk per acre occurs using soilage feeding, (3) Body weight changes were not adversely influenced by feeding chopped green forage, (4) Dairy heifers did not gain as much per day on soilage as paired controls on rotational grazing, and (5) Labor and machinery inputs increased with soilage feeding.

Title: POULTRY RANGE STUDIES

Leaders: C. D. Gordon, L. T. Smith and R. C. Wakefield

A study concerned with the value of good ranges during rearing as measured by laying house performance of pullets was continued. (1955 Annual Report, page 88).

Performance - September 1955 to August 1956.

Treatment	% Prod.	Feed Per Dozen Eggs	Mortality	Average Weight at Housing	Pounds Feed per Pounds Gain
Ladino clover	60.81	6.00	12%	4.87	7.70
Bluegrass	57.64	5.99	15%	4.84	7.82
Untreated	61.47	6.04	10.1%	4.93	7.61
Confinement	59.05	5.84	13%	5.04	7.40

While statistical treatment of the production records to June 1, 1956, favored birds reared on Ladino clover range, the records for the entire year, did not bear this out. From the data collected during 1955-56, and so far during the 1956-57 production year, there was no apparent advantage of range rearing over confinement with respect to any of the performance characters measured.

VERMONT

Title: CYTOGENETICS AND BREEDING INVESTIGATIONS WITH FORAGE LEGUMES

Leaders: A. Gershoy, F. Laing and T. Flanagan

I. Trifolium repens. Autoploid white clover 8x = 64. Sampled individual plants of C_5 and C6, derived through open-pollinations, show none to less multivalent pairing than earlier and C_1 generations. Although variation exists between individuals there is in the C_5 and C6 less meiotic disturbance, less polyspory, a higher percent good pollen and a tendency to an increase in number of ovules per pod. Seed set per pod, however, shows a negligible increase. Sampling of small populations has not revealed many phenotypes with the more desirable, highly aggressive spread. Large farm plantings will be surveyed for the purpose of selecting more spreading and persistent types. A new series of C_1 autoploids from F.C. 214207, and F.C. 214208 (Geneva, N.Y. donor) appear to be more desirable forage types. In these, meiosis is highly disturbed in both divisions, but neither multivalent association nor

polyspory has been found in comprehensive sampling. Very large differences in percentage of poor pollen were found between individual autoploids. A desired objective would be the synthesis of polyploids with less increase in cell- and organ size and with retention of, or increase in, cell number per given organ size.

II. Trifolium medium. Zig-Zag Clover. (1) Self-incompatibility and cross-compatibility: Hand pollinations of many individuals indicate complete self-incompatibility. Conversely, intercrossing of putatively unrelated genotypes (F.C. numbers) indicates cross-compatibility of varying intensities, moreover, reciprocal crossing may occasionally give significantly different seed set. Reciprocal F-1, obtained from diallel intercrossing of 5 genotypes appear to be quite self-incompatible. In general, it was found that there is a very low yield of desirable F-1 in crosses between superior parents. (2) Chromosome studies: In sectioned root tips, counts of 76-82 were read. Use of the Hill-Myers cold pre-treatment, with such adjuncts as dilute Urethane and $MgSO_4$, is helpful but uncertainty about counts persists. Aceto-carmine smearing of roots was not serviceable whereas it was quite adequate for anther studies. In meiotic studies of several thousand P.M.C. of diverse plants, accessory B chromosomes, varying commonly in number from 2-8 (and occasionally more), were found. The assumption is made here that there are 38 or 39 pairs of A chromosomes and that the counts of ca. 76 to 86 reported in the literature may be explained by varying frequencies of the B chromosomes. Reported counts of ca. 126-130 may indicate mistaken references to other species of Trifolium. Meiotic divisions are quite regular, with complete absence of polyspory. Individual plants are characterized by different percentages of poor pollen.

III. Studies in species of Lotus. (1) Karyogram studies: In the x = 6 species, i.e. L. tenuis, L. filicaulis, L. divaricatus, L. uliginosus, and the Korean diploid (L. corniculatus var. japonicus Regal (?), there are two long pairs having between sub-terminal and sub-median attachments, one pair being distinctly longer; two progressively shorter pairs have sub-median and two quite small pairs have essentially median attachments. In L. uliginosus the disparity in size between the longest and shortest chromosome is especially marked and is least so in L. divaricatus. In L. angustissimus, basic x = 6, there is in the genome a general similarity to the above named group of species, but more intergradation in lengths. In the diploid and in the naturally occurring tetraploid and in the C_1 autooctoploid the satellites, described in this species by Russian investigators, have not been found. The genome of the 2n = 24 L. hispidus and L. corniculatus (and its "varieties" or sub-species) closely resembles that of autoploid L. tenuis or the Korean species; all of the chromosomes appear somewhat shortened.

The karyograms of the x = 7 species L. arabicus and L. ornithopodioides resemble each other but differ sharply from x = 6 forms, showing much less disparity in length from longest to shortest and in having an almost median attachment. (2) Meiosis in colchicine autoploids: Good fixation is obtained in acetic-alcohol and in propionic-alcohol. Sharpest staining in anther squashes was observed immediately after transfer to alcohol. In decreasing order of rapidity, sharp staining occurs with propiono-carmine, aceto-carmine

and aceto-orcein. Pachytene stages are sharply delimited but in late diakinesis and in metaphase spiralization is extreme and the study of chiasmata is thus limited. High variability was found between species and between individuals of species, in both C_1 and later generations. Characteristically, when pairing occurs it is predominantly of bivalent type but, quite infrequently single rings of 3 (rarely 4) and chains of 3 appear. Univalents off the metaphase 1 plate are more frequent than in metaphase 2. Lagging of many univalents is observed more frequently in first anaphase and telophase. Most commonly only two dyad nuclei are formed. Univalents have been observed to divide in first and second diaphase. Marked lagging and delayed congression at the poles in telophase 2 and a high incidence of polyspory appear to be related. But if the laggards congress only four tetrad nuclei form; these may show the following features: presence of chromosomes in the cytoplasm, lobed and twin nuclei in the microspores and much disparity in size amongst the 4 spores. When polyspory occurs size differences in microspores is extreme. In general, the percentage of poor pollen is higher than the percentage of polysporic P.M.C. but the reverse has been found in a C_2 plant of autoploid L. uliginosus. Within the x = 6 species the Korean form shows no polyspory though meiosis is disturbed. In L. tenuis the incidence of polyspory is highly variable, -- more marked in the C_1 and, generally progressively less in some individuals of later C generations than in others. This is also true of C_1 to C_3 of L. uliginosus. C_1 plants of L. filicaulis show more polyspory than C_1 L. divaricatus. Naturally occurring tetraploids of L. angustissimus have normal meiosis, variably small seeds and many seeds per pod; the C_1 autooctoploids show extreme meiotic disturbances and very high polyspory. Within the x = 7 species C_1 autoploids of L. arabicus and L. ornithopodioides have markedly aberrant meiosis and high polyspory.

IV. Relation of autoploidy to self-fertility. Autoploids of the autogamous species L. ornithopodioides and L. angustissimus are self-fertilizing. Similarly, self-compatible L. uliginosus and the Korean species remain self-fertile. The essentially self-sterile L. tenuis shows variable self-compatibility in some individual autotetraploids but not in others. This sort of variability in self-fertility has been observed in plants of the naturally tetraploid L. corniculatus.

V. Meiosis in F-1 and later generations of experimental hybrids between C autoploid L. tenuis and L. corniculatus. F-1 hybrids of C_2-C_4 L. tenuis x L. corniculatus (Empire and European types) (by students Mears and Erbe) are quite fertile and show bivalent pairing. Some pollen sterility occurs. To some extent meiotic instability is related to lack of disturbed meiosis in the L. tenuis parents. F-1 hybrids with the Empire strain of broadleaf are fine stemmed, small leaved and late flowering. The hybrids with the European types (Mansfield and Viking) are coarser stemmed, wider leaved and somewhat earlier flowering. Backcrosses to either species (exact parents or other individuals) phenotypically show dosage effect of number of parental genomes represented. Meiotic stability is related to stability in the L. tenuis autoploids. The hybrids have been advanced to the Syn. 3 generations and new, promising F-1 crosses have been obtained (by Erbe).

Title: THERMOPERIODS AND APOTHECIAL INITIAL PRODUCTION IN THE FUNGUS SCLEROTINIA TRIFOLIORUM ERIK.

Leaders: Thomas Sproston and Daniel Pease

Cultures of Sclerotinia trifoliorum were incubated, after preincubation at 24°C, at several temperatures for definite time periods by moving cultures manually. Series A cultures were incubated for 8 and 16-hour periods and series B for 4 and 20-hour periods. All cultures were subjected to 7°, 15°, 21°, 24°C in all possible combinations. Similar culture plates were held continuously at the same temperatures.

From the data obtained several diurnal thermoperiods influence apothecial initial production. More than 100 fundaments were produced per plate in the 4 and 20-hour periods held at 7° and 21°C, 24° and 15°C, 7° and 15°C, 15° and 21°C. The highest number of apothecial initials was produced in the 8 and 16-hour periods. Plates held at constant temperatures continuously produced 13 apothecial initials at 15°C and 34 at 21°C.

It has not as yet been possible to determine the ideal thermoperiod required by the organism because of the numerous possible combinations of temperatures and time periods. Seven degrees and 21°C for 4 and 20-hours seems to be important because some cultures held for 7 months at a continuous 15°C produced fundaments in 15 days when subjected to thermoperiods. At this thermoperiod 563 apothecial initials were produced per culture plate. Apothecial initials have been produced in 40 days in the laboratory. In nature, a period of 7 months is required. Light is essential for maturity of apothecial initials into apothecia. Further results will be published later.

Title: MODIFIED AND NORMAL BAND-SEEDING OF FORAGE CROPS

Leaders: A. R. Midgley and K. E. Varney

A Brillion Seeder with fertilizer hopper was modified so that the seed and fertilizer ran together and the mixture directed between the front and rear rollers of the machine. This placed the fertilizer and seed together in bands about 7 inches apart. Work was also done with a grain drill converted to a band seeder. This also placed the fertilizer and seed in bands, but they were not run together as the fertilizer was placed slightly below the seed with some soil between them. These field trials were conducted in five counties throughout the state using red clover and two varieties of alfalfa and birdsfoot trefoil. The fertilizer used was superphosphate alone (0-20-0 at 500 pounds per acre), P-K (0-25-25 at 250 pounds per acre), and N-P-K (8-16-16 at 250 pounds per acre). The following results were evident this first year: (1) Very good stands were obtained with less seed and fertilizer than by broadcast method, (2) Birdsfoot trefoil, which is often slow to become established, shows considerable vigor and the Mansfield type was practically equal to alfalfa in growth, (3) There was no evidence of "burning", even when

complete fertilizer was used directly with the seed at these rates. However, the soil was moist and there was a light rain soon after these seedings were made, (4) On two fields where superphosphate was used alone and placed together with the seed, a marked potash deficiency resulted. It was much more severe than where no phosphate had been applied. Subsequent greenhouse trials showed that the superphosphate on these two soils induced a marked potash deficiency. When potash was used at time of planting or as a subsequent broadcast application, normal growth resulted, (5) When phosphorus alone was banded below the seed (with drill) the deficiency was much reduced, and (6) The use of nitrogen with minerals had no marked effect on the legumes, but the native grasses and weeds grew more readily and were darker green color.

Title: EFFECT OF SIMULATED PASTURE MANAGEMENT PRACTICES ON THE PERSISTENCE, QUALITY, AND YIELD OF SEVERAL BIRDSFOOT TREFOIL SPECIES AND VARIETIES

Leaders: G. M. Wood and K. E. Varney

Original seeding was made on light soil in 1954 (1955 Annual Report, page 89) and abandoned after one harvest year because of serious decreases in stands for all varieties and treatments. Seedings on heavy soils were made in 1956. First year data on these soils will be obtained in 1957.

Title: HIGH-MOISTURE VS. WILTED GRASS SILAGE FOR RAISING DAIRY CALVES

Leaders: J. A. Newlander and W. H. Riddell

During the past four seasons the nutritive values of high-moisture grass silage and wilted grass silage were compared in the raising of dairy calves. Identical twin calves were used for the trial and fed the silage ad libitum. The animals on the wilted grass silage consumed more dry matter and consequently made correspondingly greater gains. No preservatives were used the first two years, but sodium metabisulfite was added to the high-moisture material the last two years. This addition did not affect the relative results. The dry matter consumed and the gains made averaged about 10 percent higher for the calves on the drier silage.

Title: CONSUMPTION AND UTILIZATION OF FORAGE BY CHICKENS

Leaders: G. M. Wood, D. C. Henderson and R. T. Smith

A cafeteria or free choice technique was developed to determine forage preferences of chickens (1953 Annual Report, page 78). Replicated green house flats of weeds and 20 forage species and forage mixtures were served White Rock pullets on range and in confinement in a series of tests. No significant differences in consumption between bromegrass, ryegrass, alfalfa, orchardgrass and Ladino clover were measured. However, these five species

were consumed in significantly greater amounts than Kentucky bluegrass. Birdsfoot trefoil was one of the least liked species.

In another experiment post-mortem examination of the crop contents was found to be a more precise method of studying forage consumption. Where appreciable quantities of a particular forage were eaten it was not difficult to identify the species. It was found that certain perennial weeds such as chicory, dandelion and plantain, are eaten in quantity. White Rock cockerels in this study consumed four times as much forage as did the pullets. Further studies relating forage utilization to laying house performance are in progress.

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: George B. MacCollom

Initial studies on the effect of insects on birdsfoot trefoil seed production indicate that they cause a serious reduction in seed yields. Four insecticides, endrin, toxaphene, DDT, and a combination of DDT and dieldrin, were used to evaluate control effects in a 5 x 5 Latin Square, each cell measuring 20 x 100 feet. Applications were made at the time of peak meadow spittlebug hatch using a low volume low pressure sprayer applying 20 gallons per acre. Seed yields on treated plots were increased approximately 50%. Treatment effects also showed significant increases in the number of flower clusters per stem, and seed pods per umbel. No significant increase was shown in the yield of forage. The meadow spittlebug, Philaenus leucophthalmus (L.), together with several species of Mirids were observed to cause bud blast, blossom drop and flagged terminals.

A state wide survey of clover root borer, Hylastinus obscurus (Marsham), infestations in the fall months on stands of first harvest year red clover was initiated in 1955. This insect has been found in all counties of Vermont, but infestations have not been found in excess of 30 percent except in Rutland and Addison counties where they were found as high as 84 percent.

WEST VIRGINIA

Title: ALFALFA VARIETIES

Leader: O. J. Burger

Of the seeding made in 1954 (1955 Annual Report, page 92), Narragansett outyielded Vernal in 1955, but Vernal produced nearly a half ton more dry matter per acre than Narragansett in 1956. The yield for Vernal was 3.40 tons per acre in three cuts. Rhizoma continued its high yielding performance with 3.63 tons per acre.

Of the three varieties, Narragansett, Vernal, and Williamsburg, Narragansett removed the greatest number of pounds of potassium per acre. Application of 150 pounds of potash to plots of Vernal and Narragansett alfalfa produced a 14 percent increase in yield. A 17 percent increase in yield was obtained by applying 300 pounds of potash. In the fall after the second growing season, there were about 50 percent more alfalfa plants in the potash plots than in the plots receiving no potash.

Title: THE INFLUENCE OF FERTILITY AND MANAGEMENT ON SEVERAL LADINO CLOVER-GRASS MIXTURES

Leaders: O. J. Burger, C. Sperow and D. R. Browning

Description of treatments, both fertilizer and management for the years 1952, 1953, 1954, and 1955 can be found in 1953 and 1955 Annual Reports, pages 79 and 92, respectively.

An additional fertilizer treatment of 0-0-160 was applied in 1956 in place of a no fertilizer treatment. The yields in pounds dry matter per acre of the Ladino clover plus grass, the Ladino fraction and percent of the Ladino fraction of total are given below: (Average of 5 Ladino clover-grass mixtures, 5 cuts, 4 replications on Wheeling fine sandy loam.)

Treatment	Ladino Clover Plus Grass	Ladino Clover Fraction	Ladino
	lbs.	lbs.	%
0-0-0	3297	397	12
0-80-0	3127	279	9
0-80-80	4362	756	18
40-80-80	4519	568	13
0-160-0	3432	342	10
0-0-160	3933	829	21
0-160-160 + 0-0-160 after 1st cut	5136	1679	33
80-160-320	5394	693	13

The Ladino clover fraction was increased considerably when the 0-160-320 application was split as follows: 0-160-160 plus 0-0-160 after the first cutting. This effect was greatest in the smooth bromegrass and reed canary grass mixtures. The application of nitrogen lowered the percent Ladino fraction.

Title: NITROGEN ON BLUEGRASS

Leaders: G. G. Pohlman and N. M. Baughman

Nitrogen fertilizer at rates of 120, 240, and 360 pounds per acre was applied for the third year on bluegrass sod at two times and two levels of fertility. During 1956 the plots with high fertility level (1600 pounds 0-20-20 applied in 1954) averaged 349 pounds more dry forage than the plots at the low fertility level (800 pounds 0-20-20 applied in 1954).

The application of nitrogen increased yields in all treatments, but the increase was less than in previous years because of the presence of white clover in the plots without nitrogen. Nitrogen fertilizers decreased the clover in all plots, the decrease being related to the amount of nitrogen applied.

The increase in yield following nitrogen application influenced yield for a variable period of time depending on both time and rate of application. The applications in April increased yields as measured by clipping as follows: 120 pounds of nitrogen influenced yield until about July 15; 240 pounds of nitrogen influenced yield until about August 5; and 360 pounds of nitrogen influenced yield until about August 15. Applications of nitrogen made July 31 increased yields until September 15 for the 120 pound application, until October 1 for the 240 pound application, and until October 30 (the end of the season) for the 360 pound application.

The application of 360 pounds of nitrogen in three 120 pound increments applied in April, July and September gave the highest yield of forage.

USEFUL TECHNIQUES

Preservation of Fungi

Many forage crop pathogens, with the exception of some isolates of Rhizoctonia and Pythium, have been maintained in soil in test tubes for one year or longer without losing virulence and apparently without mutation. These include Ascochyta, Stemphylium, Helminthosporium Fusarium, Pseudoplea, Stagonospora, Pleospora, and Myrothecium.

Approximately two inches of soil is placed in the test tube, moistened, and autoclaved. A fresh isolate of the fungus is placed underneath the soil surface and incubated at room temperature. Mycelium grows in the moist soil and as the soil dries the strands adhere to the particles. When a culture is needed a few grains of the dry soil can be transferred to agar slants or plates. This is not a new technique.

Sporulation and Inoculation with Pseudoplea

Most isolates of Pseudoplea from legumes sporulate well on V8 juice agar held in diffused daylight at 18-22°C. By using the soil storage technique described above, numerous ascospores are produced within one week. Good infection has been obtained by inverting Petri plates containing sporulating cultures over young alfalfa and Ladino clover plants in a moist chamber. The plants should be kept moist for 24-36 hours at 15-22°C.

Root-tip Smears

The smear technique used at the Laboratory for making chromosome counts for the most part has been the one described by Hanson and Oldemeyer (Stain Techn. 26:241-242. 1951). With certain modifications, this has proved superior to all other methods tried. The modifications may be worth noting: (1)* When root tips are collected they are usually left in aceto-carmine a minimum period of 3-4 hours rather than for 30 minutes. If the vials are stored in a refrigerator the period may be extended to 10 days or 2 weeks. (3) The slow heating is accomplished by holding the end of the slide with root tip in 2 drops of aceto-carmine at a distance of 4-5 inches above the flame from an alcohol lamp until the liquid has nearly evaporated. Patience is required. (6) The smearing is done by applying the length of a coarse steel needle with pressure and a cutting operation after maceration with the flat end of a wooden needle.

Trials with this and numerous other suggested methods have so far not resulted in a completely satisfactory solution for a technique for <u>legumes</u>.

*Numbers refer to comparable steps in the paper cited above.

Method for Rooting Alfalfa Cuttings

The common technique for rooting alfalfa by placing short lengths of stems in moist sand has not been entirely satisfactory. Greatly improved rooting was obtained by using the following procedure:

Two-inch lengths of the younger portions of a stem should be used. Expanded leaves, except one or two, should be clipped off and the lower ends of the stems placed about an inch deep in gravel that is irrigated at hourly intervals. The gravel (relatively fine) is a good supporting medium for the cuttings and hourly flushing by irrigation with tap water or a dilute nutrient solution provides adequate moisture and excellent aeration. A dilute nutrient solution may be made by dissolving 205 mgm. calcium nitrate, 41 mgm. potassium phosphate, 60 mgm. magnesium sulfate and 8 mgm. of ferric phosphate (pearls) in a liter of water.

In trial runs, more than 50 percent of the young cuttings rooted, but less than 25 percent rooting occurred when basal cuttings were used. There were large clonal differences in rooting and particularly in the percentages of rooted cuttings. Previous tests where rooting hormones were used did not indicate increases in percent rooting of alfalfa. Root initiation requires between three and four weeks, when the cuttings are placed at normal greenhouse temperatures and are flushed hourly as indicated above.

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